# THE WORLD IN ITS WORKSHOPS

A CRITICAL EXAMINATION

Of the Fabrics, Machinery, and Works of Art

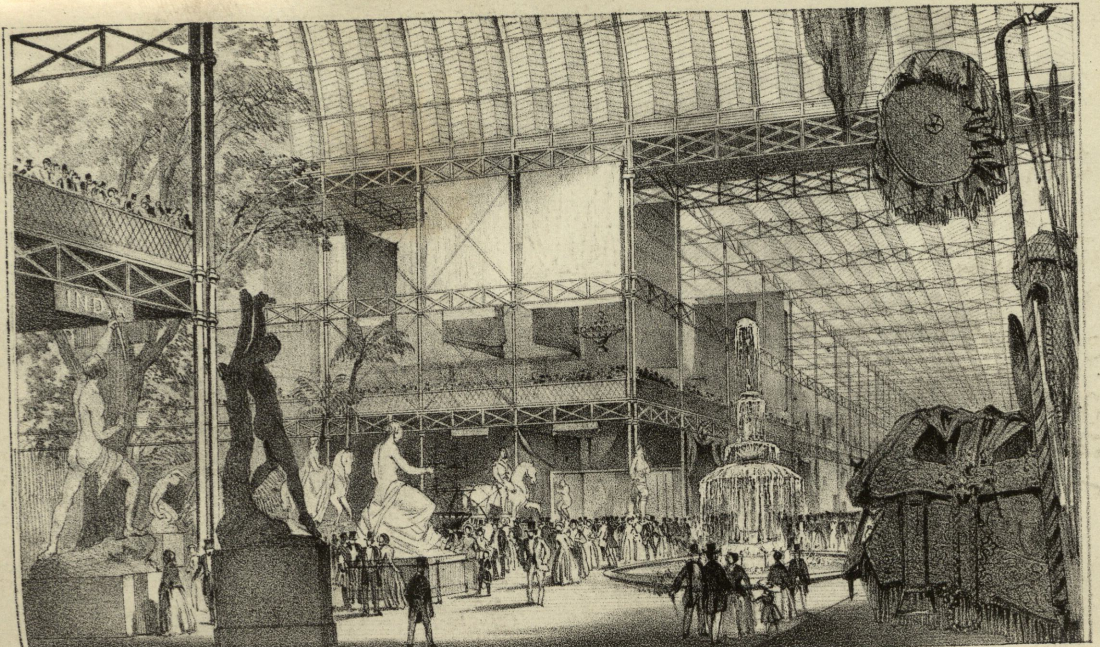
CONTAINED IN

THE GREAT EXHIBITION.

BY JAMES WARD.



London :
WM. S. ORR & CO.

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THE

# WORLD IN ITS WORKSHOPS:

A PRACTICAL EXAMINATION OF BRITISH AND FOREIGN PROCESSES OF MANUFACTURE,

WITH

A CRITICAL COMPARISON OF THE FABRICS, MACHINERY, AND WORKS OF ART

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**METALS, MACHINERY, AND GLASS.**



LONDON:
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PATERNOSTER ROW.

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# INTRODUCTION.

"Have I made up my mind upon the Exhibition?" you enquire. I have not; nor, indeed, can I at present. I have scarcely recovered from the bewilderment and confusion of mind which is incident to such a singular sight. In that wondrous structure there is study for a month, reflection for a year, and instruction for ever. At present I can merely discern a few outlines of its great industrial features, and the filling up of each outline is a world within itself. Look at that machine, for example; simple as it seems, it is the epitome of man's industrial progress—of his untiring efforts to release himself from his material bondage. And how many thoughts, ideas, and experiments have been expended upon that apparently simple structure—how many brains puzzled, pained, ay, even paralysed, to bring it to its present usable state? However, let us leave the comparative anatomy of that industrial phenomenon to some mechanical Cuvier—he alone can do justice to its illustration. Nevertheless, just analyse that fabric on the opposite side of the building; it is so delicate in texture, and so beautiful in colouring. It would sorely puzzle even a practical mind to enumerate the processes through which it must have passed ere it arrived at its present finished state. Look where you may, in fact, the same difficulties present themselves; the mind is barely able to take more than a skin-deep glance at the varied and surrounding objects, unless it happen to have been instrumental in the production of either one or other. And even if we make this concession, how much have we diminished the difficulty? "I made that piece of silk down at Manchester, in a Jacquard loom, so I know all about it," exclaims some well-meaning but dogmatic weaver, if you will only encourage him to speak his mind. Indeed, so my dear man, because you wove that piece of silk you conclude that you know all about it. You received, for instance, the warp in a dyed state, of which, I presume, you know little or nothing, for dyeing involves a knowledge of the rather mysterious science of chemistry, which requires a special study. That is only one stage preceding your operations upon it. Next comes the "throwing" of the silk, which you

probably never saw; still it is a study of itself, requiring considerable mechanical skill, great knowledge of the raw material, and the capacity to make the most of both. Then there is the raw material itself. What know you whence it came, how cultivated—whether by Christian, Mahommedan, or Chinese? We need go no further. *What you do know is invaluable;* but it is only a tithe of the knowledge comprised in that simple piece of silk. You know how to throw the shuttle, *perhaps* to put the warp in the loom, to pick off the *fluff*, if there chance to be any, to weave so many shoots to the inch, and to take home the work when finished for your pay. That is about the extent of your knowledge; however, it is as much as can be expected, and is very creditable to you. *Ex uno disce.* This simple but dogmatic weaver is a fair type of the majority of what are called "practical" spectators.

"Do I mean to say that *practical* minds are not capable of availing themselves of the improvements they may see in the Exhibition?" I really do. Take the mass of what are called "practical" minds, as a body they are nearly as inapt to appreciate and apply improvements as the mere loungers and idlers who saunter through the treasure-stored avenues of the building. They will look with perhaps a shrewder eye at the several objects upon the production of which they may have been partially engaged; but the result, in a majority of cases, will prove little more than a negative; they must wait for the thinking few to lead them, from whom all practical knowledge of a valuable nature is derived. These few are the stars that guide the many in the true path of improvement; but as yet they are below the horizon, gathering light, as it were, to shine steadily and clearly on the future course of their humbler "practical" brethren.

You remember the picture which political economists delight to draw when they want to demonstrate one of their favourite theorems.* They paint a man brought up in civilized life as cast upon a desert island; he is without food, without clothes, without fire, and without tools. "We see the human being," they say, "in the very lowest state of helplessness. Most of his preceding knowledge would be worse than useless, for it would not be applicable to his new position." By way of alleviating his case they say, "Let the land upon which he is thrown produce spontaneous fruits, let the climate be most genial, still the man would be exceedingly powerless and wretched." No doubt. But why? "The helplessness of this man's condition," they tell us, "would principally be the effect of one circumstance: *he*

* "Capital and Labour:" Charles Knight.

*would possess no accumulation of former labour, by which his present labour might be profitably directed.*"

This is a somewhat fanciful picture, you will say; but has it no *pendant* in practical life? Place the same individual, for instance, in the Grand Transept of the Crystal Palace, with the prodigies of art, of science, and of labour before him, where the resources of human ingenuity are displayed in every variety of substance and form, and the chances are that he would experience a perplexity of mind fully equal, if not so painful as though he were upon the desert island, and the presumed destitution staring him in the face. *What* could he look at first, and *how* would he look at it, seeing that his preceding experience, or, to use the precise term of the sages just cited, his *accumulation of knowledge*, would be of comparatively little avail? On the one hand, he would scarcely know how to provide against the destitution staring him in the face; on the other, he would be equally puzzled to worm his way rightly and instructively through the intellectual zigzag in which he must naturally find himself. Look where he might, his eye would soon become embarrassed by the novelty of the scene, both in form and material—

> "A scene so various that would seem to be
> Not one, but all the world's epitomé."

His first sensation—and it must have been that of thousands who have visited the Exhibition—would be that of wonder and surprise at the overwhelming mass of beautiful objects which the skilled industry of the age had ranged before him; when he had partially recovered from this state, his imagination might chance to take a turn in such a region of fairy revelry, but some time must necessarily elapse ere reason could exercise her influence, and calm down his mind to sit quietly on its judgment seat, to enable him to view things in a clear and truthful light. His state of mental helplessness, in fine, would be equally conspicuous whether contemplating the *embarras des richesses* in the great ark of industry, or placed in the supposed lowest state of human existence on the desert island. He would lack the necessary instruction in both instances.

In the retreat from Moscow—"what has the retreat from Moscow to do with the Exhibition?"—Simply this, that the human mind, under the most opposite circumstances, sometimes exhibits a similarity of action, however the motives may vary. In the retreat from Moscow some of the soldiers were heavily laden with the spoils of the city, and Segur, in his account of that terrible event, gives a painfully ludicrous description of their embarassment when compelled by fatigue

to abandon a portion of their treasures. There must have been a strange conflict in the minds of those harassed troopers—a fearful struggle between greed, on the one hand, and the apprehension of death on the other—as to what they should retain and what abandon in their hurried, uncertain, and melancholy route. A similar feeling, it is fair to presume, pervades the multitude of spectators while wandering through the wondrous avenues of the Exhibition, from the sheer want of a simple and judicious direction; and the majority must leave those trophies of a peaceful conflict with the painful impression that they are utterly incapable of estimating the relative merits of the industrial combatants. Like the soldiers of Napoleon, the spectators are compelled to leave the *spolia opima*, if we may be allowed the phrase, behind them—not solely from the fatigue they endure to acquire it, but principally from incapacity to form a correct notion of its value. And it is in the nature of things that it should be so. Did you ever experience a similar sensation when your young feet first paddled along the sea-shore? Had you then no difficulty in making a choice of the objects everywhere around you? We had. At the first sight of that multitude of shells and stones, which were so beautiful and diversified in appearance, so clear and so bright, the receding waves having just washed over them, our young mind was strangely perplexed. At length we picked up one, then another, then a third, and so on, the last always appearing the most beautiful, until we had gathered so large a quantity that we could scarcely carry them. Then came the time for ultimate selection—the most difficult of all tasks to our youthful fancy and taste, until reason determined the point to lie between our strength, on the one hand, and our choice on the other. The question, therefore, was partially settled, and we reduced our quantity to a comparative few, which appeared to our wondering and uninitiated eyes as the most rare and beautiful specimens of their kind. Nevertheless, we were guided more by caprice than by judgment; and showiness of appearance rather than intrinsic beauty and utility, which instruction alone can discern, were the prevailing qualities of our choice.

"What notion have I formed, then, of the Exhibition, after all my bewilderment and perplexity?"

I will endeavour to tell you. I think that its friends are a little too sanguine, and that its enemies are a great deal too doleful and condemnatory. It is much more likely to effect the good anticipated on the one hand than it is to inflict the evil so gloomily depicted on the other. Let us avoid extremes.

"Premature, do you say?" Not in my opinion; it has taken place at precisely the right time; it is a natural consequence of a preceding cause. The error on the part of several of its opponents consists in mistaking it for a cause instead of a consequence. The elements to produce such a result have been long at work, and something of the kind has been quietly and gradually developing itself in the practical and calculating mind of the world for these years past, although the latter may be, in some degree, startled at its peculiar aspect and bearing. In fine, I view the Exhibition as natural a complement to the preceding movements of material industry, as a field of battle is to the concentration of armies, for

"Coming events cast their shadows before."

"The comparison is strained, is it?" In what way is it strained. Has not all Europe been strenuously endeavouring, for the last quarter of a century, to bring each other into closer connection? Have not railways enabled the Englishman to visit Vienna and Berlin, Paris and Dresden, as easily as he could Manchester and Edinburgh some twenty-five years ago? And have not the same lines of communication enabled the several inhabitants of those cities to pay England a similar compliment? Having visited those great central points of civilisation, and finding something in each different to our own, it is natural that we should treasure that something in our minds, and also endeavour to realise it for the gratification of our senses. We see, for example, a piece of furniture, a pattern of silk, a porcelain vase, or any other object which strikes the eye as differing from what we are accustomed to, and the desire is naturally awakened to possess it. It is purchased, brought home, and most likely admired; others do the same, until the whole circle of society, both here and abroad, becomes more or less influenced by similar feelings. The possessors of these exclusive objects naturally prize them, and in several instances unduly vaunt their excellence, which creates a feeling of rivalry on the part of others who are not so fortunate, but who are also equally desirous to obtain them. The dealer then steps in, and with the cunning belonging to his craft, turns the public weakness to account, by flattering the *few* who possess these rare and exclusive objects in order that he may supply the *many* who desire them. This dealer is no better judge of the relative excellence of foreign and home manufactured objects, nor in many instances so good as those who possess them, but with the turn-a-penny tact which he has acquired, he assumes a thorough knowledge of both. The dealer, in this in-

stance, becomes, as it were, the arbiter of home and foreign productions, utterly regardless of every feeling but one—"which will yield me the most profit?" The result inevitably follows—our manufacturers complain, our artisans complain, and our general producers complain at what they call, and justly, too, in many instances, the undue preference given to foreign commodities. Under these circumstances what would common sense suggest? Unquestionably a fair, a just, and an equitable comparison between the objects manufactured abroad, and the objects manufactured at home, in order that there should be no delusion as to relative excellence. And how could you obtain such a comparison but through the medium of the Exhibition, or something analogous to it? Endure me for a moment. You have not only railways to whisk mankind about the world, but you have the incomparably quicker instrument—the electric telegraph. When you see the charged-wire obedient to the commands of man, not only to move as he directs, but to speak as he bids, when, in short, he has reduced by this powerful agent time and space to an almost incomputable quantity, is it not natural to expect that everything within the sphere of human influence should be proportionably affected. The momentum once given to the elements of man's social existence, it never ceases until the whole is perceptibly influenced and homogeneously directed. When the quick-footed step on quicker than is their wont in the race of life, those of slower pace must make a proportionate measure in their footsteps, or they will be grievously worsted in the race, if indeed they do not entirely drop off, and even lose sight of the rear. If one portion of mankind adopt the spirit of improvement with greater aptitude than another—if they enrich themselves ere the other have made up their minds to even recognise its existence, one of two things must ensue—either the sluggards must quicken their mode of action, or they will be thrust aside by others of more resolute aim and more determined energy. It is not in the nature of things that the active and stirring minds of our workshops and counting-houses should sweep round the world in search of new materials and new wants without disturbing those of a more sluggish and sleepy disposition; but, happily for the latter, it is so arranged in the providential government of human affairs that what frequently appears contrary to our interests, ultimately proves to be beneficial; and seeing also that change is a condition of our existence, it is much more salutary and judicious to prepare for it, than blindly attempt to resist its progress. In a council of owls you would naturally expect the proposal to reduce the light to the dimness of

their orbs, but in an assembly of rational minds, the suggestion would rather be to enlarge the power of the eye—to improve its visual faculty—so that the full blaze of intelligence might beam upon it.

However "strained," then, the comparison may be between the Exhibition as a sequence to the industrial movements of mankind, and the field of battle as a sequence to the concentration of opposing armies, there are one or two points of resemblance that surely must strike you. Let us quietly examine the phenomena as they present themselves on both sides the comparison. The industrial forces of the world have long been moving to a single point, just as much so as the military forces of Europe were, preceding a great single result; and the only perceptible difference between yon dark column of machinery (the metaphor allowed), which has marked a line for itself right through the territories of industry—tumbling, tossing, uprooting, and whisking settled interests about as though they were old rags only fit to be pulped into new forms; and the armed battalions of troops is simply this—that one leads to a victory over the moral forces of man's nature, while the other leads to a conflict of the evil passions of his nature, as though man was born for mere savage and destructive pastime. The one, it is true, is a sustaining and creative rivalry; the other a destructive and desolating conflict. The first teaches man, though the instruction is somewhat roughly given, how he may improve his moral and social condition by augmenting his productive power; while the latter has no other effect but to inspire him with brutal feelings, and to inflame the savage instincts of his nature. The operation of the industrial and moral forces of man's nature must therefore naturally terminate in some such scene as the Exhibition in Hyde Park; and such a terminus is just as appropriate as is that of his evil passions in the scenes enacted on the plains of Leipsic or of Waterloo. Certes, the peaceful trophies of the one are a more soul-cheering sight than the sanguinary results of the other, so that the Exhibition, if the comparison may be continued, simply denotes a change in the ordinary strife of the world; and in lieu of fabricating weapons for mutual destruction, mankind seem tacitly agreed to rival each other in the manufacture of commodities essentially requisite for their mutual advantage.

It is simply a transfer of skill and industry—from bullets of lead to bales of cotton, and in lieu of conflicting armies we are destined, for some time at least, to endure conflicting tariffs. The movements of the industrial and military forces of the world have, therefore,

been in nearly parallel lines; and there is this condition attached to the movement, that those who wish to do justice to themselves and to their fellow-members of the community must become thoroughly prepared for the industrial conflict, or they will be thrust to the rear, or trodden down by their more disciplined competitors.

"What good do I expect to accrue from the Exhibition?" This. The manufacturer, the artisan, and the consumer, now know in what relation they stand to the foreigner, as regards their respective interests. The first will naturally direct his energies to the improvement of his fabric; the second will endeavour to augment his skill; and the third will be enabled to see more clearly how to guide his judgment to a right selection in his choice of objects. Many misconceptions will be obliterated, and many errors removed; the whole circle of the producing and consuming world stand then on a perfectly fair footing to justly appreciate and understand each other. This, indeed, is a great good. Great and inestimable, however, as this good appears, the Exhibition presents another of equal importance in relation to our social and moral well-being. It is a great advantage to have our eyes opened; it is still greater to have them opened in a right direction. The English artisan now knows in what degree he is inferior to the foreign artisan, and in what degree he is superior; and not only has the artisan acquired this important knowledge, but the manufacturer and the consumer know likewise. So that the former need not be deterred from improving his skill by the prejudiced ignorance of the one, or the too easy credulity of the other. The artisan, for the first time in the history of the world, has obtained a clear stage and no favour; it will depend, in a great measure, upon himself whether he be capable of turning so excellent an opportunity to good account.

"Wherein do we excel, and wherein are we deficient?" We excel in administering to the ordinary wants and comforts of the world, but it must be confessed that our manufacturers and artisans are deficient in beauty of design, in high artistic conception and skill, and in decorative art, as compared to the foreigner. The following remarks, in the first edition of the *Wealth of the World in its Workshops*, have been fully borne out by the fruits of the Exhibition, and explain, in some measure, the reason why we are inferior to the foreigner in these several respects. In speaking of the British manufacturer, we observed:—"That in those branches of operative skill and art, which are peculiarly British, they will prove unrivalled; and that, even in some in which the superiority of our continental neighbours is rather a lingering tradition from the past than a reality of the present, they

will be able to assert an equality of excellence which has hitherto been injuriously denied them. There are others, however, in which we can scarcely hope to find them pre-eminent—in those principally in which the perfection of the art of design is an indispensable element. There are many reasons for the present superiority of, at least, our French neighbours in this respect, and it will not be uninteresting or uninstructive to discuss the chief of them briefly in this place.

"There is in France, as compared with England, so little employment for juvenile labour, that the rising generation has ample leisure for some preliminary instruction before it is summoned to the active duties of life. In and around all our great seats of manufacturing industry, a child can be put to some use, so as to contribute something towards the support of the family, at a very early age; and hence we find that, when grown up, they have acquired no accomplishments in the way of education, farther than such as enable them to read a newspaper and (with some difficulty) to write a letter. For the peculiar occupation to which they are destined they receive no preparatory education at all; they take to it, when very young, nothing more than their natural strength and mother wit; and they grow up as nothing more than the motive power of the tools they are taught to use, or the tools of the motive power which it is their business to attend to. They thus become most expert workmen—and, perhaps, they owe a portion of their excellence in this respect to all their mental energies being concentrated in what may be called the manipulation of the task they are performing. To that task they daily apply themselves without troubling their heads about how their labour might be abridged, or how the product might be improved. But in France, a contrary system is prevalent, arising from the different circumstances of the two countries. Children, as we have said, have there a few years for education before they are called to contribute to their own support; and the State has wisely provided that this education shall be such as will be of some service to themselves and to society in after-life. The art of design is a principal feature in it—though not to the exclusion of the ordinary rudiments of reading and writing—and thus it may be truly said, that the child is made the father of the man, for he acquires in childhood that which will be most serviceable to him in manhood, and which can rarely be acquired after the cares of manhood have begun, and the habits of self-satisfied ignorance have become confirmed. It is this early and appropriate education which renders almost every operative in France

an *artist* likewise in the branch of manufacture to which he has been devoted. Hence he has a superior *taste for the beautiful* to what the English operative can boast; and the fruits of this elevation in the capacity and imagination of the French operatives are naturally observable in the greater delicacy or grandeur of French designs, as the occasion may require. We do not mean that the French operatives universally supply the designs for the productions upon which they are engaged; but when they do not, it is a necessary consequence of their being such *respectable* masters of the art of design, that those who make the art of design a profession, must be *very superior* masters of it indeed, and that the operatives themselves, from their capacity to appreciate the ideas of the designer, must be capable of interpreting and expressing them in the execution of the work more effectually than if they had no more sense of their beauty than the scene-painter, however expert in the use of the brush, may be supposed to have of the beauty of a Claude or Canaletti.

* * * * *

"But the Exhibition, while it cannot fail to prove highly instructive to our skilled artisans, by the *studies* which it will bring before them for the enlargement of their conceptions and the improvement of their taste, will also undoubtedly conduce, in another manner, to the elevation of their calling in an intellectual, and of their condition in a worldly, sense. It has generally been assumed, as we have before remarked, that the inferiority of the British artisan in design is a natural defect, and that taste is a gift which has been but very moderately vouchsafed to him. But this theory will not bear a philosophic examination. Always and everywhere the development of any faculty, and its progress towards perfection, have depended upon the demand for its employment, and the rewards offered for its exercise. If the great body of the people do not appreciate, or have no relish for, any particular kind of excellence, the talents which could otherwise display it will remain dormant. Thus, while the people of this country had no taste for music of a refined and elevated character, we had no native composers in the higher walks of the art; but since the public taste has been educated in this respect, and the great body of the people can enjoy and require what their forefathers had no ear for, we have had a galaxy of composers, scarcely inferior to the brightest stars of Italy. And so it has been, and will be, with our skilled artisans. If they have not hitherto shone in the higher walks of ornamental art, it has been because the mass of the community has not appreciated it, and that there has therefore been no

sufficient demand for its production to reward its cultivation. But let the public taste become educated in this respect—and what means so powerful to this end as such Exhibitions as that intended?—let there thus arise a demand for greater excellence in decorative works than those which satisfy the ignorant simplicity of the present day, and latent talent will be evoked to supply it. Elegance in dress, in furniture, in household fixtures, in every requisite for personal and domestic enjoyment, will conventionally become one of the prime decencies of life; and who can doubt that such a consummation would greatly elevate the worldly condition of the skilled artizan; while, as callings are always estimated according to the intellect required in their exercise, it would equally elevate him in the scale of society.

"We must also solicit attention to another consideration. The skilled artisan in this country will always possess one great advantage over the artisan of any other, namely, the vast abundance of capital which in this country is always ready to avail itself of his talents. It will be said that the artisan has not found this to be invariably the case; but this seeming contradiction to the assertion is easily explained. Hitherto our artisans have had little more than mere manual skill to offer, and the capitalist has regarded them, according to the different branches of employment for which they are fitted, as being all nearly equal to each other in this respect, that it has not been worth his while to make any discrimination between them. If he required a hundred hands, he went into the appropriate labour-market, and took those out of the number competing for work, who were willing to work, on the lowest terms. This practice is very injurious to the artisans as a body, for not only have the best been excluded from employment by the competition of the worst, but the rate of remuneration became fixed by what the very worst hands were willing to accept. This has arisen from the difficulty of discovering beforehand any difference in the value of the mere manual labour of individuals. The artisan has had nothing to offer to the competition of capitalists, for the competition has been the other way, manual labour competing for employment. But how different would be the case, if the artisan was an artist also—one not only with hands to execute, but with a head to design? This would at once do away with the equality in the value of the services of all, which has reduced all to the necessity of contending amongst themselves for employment, the strange principle of their rivalry for the notice of the capitalist being, not who can do the best

work, but who will sacrifice himself for the worst wages. Let the artisan, we repeat, become an artist also, and this would be done away with; for though there may be no difference between the value of one pair of hands and that of another pair of hands, there will always be a difference between the value of one man's intellectual gifts and those of another man. If then the artisan had not only a pair of hands but a head also to be employed, his situation would be most happily reversed. Instead of waiting in the labour-market for the chance of being the lowest bidder for employment, he would go to the capital-market to find the highest bidder for his services. Capitalists would then be the competitors for high-priced talent, and not artisans the competitors for low-priced work.

"Lastly, let none be so near-sighted and narrow-minded as to urge that the Exhibition will be a stimulus to foreign nations to excel in the industrial arts. We trust that it may be so, and that it may conduce to their rapid progress in prosperity. We wish to see them rich and flourishing; for what reason have we, even on the score of selfishness, to desire that they should remain in poverty or fall into decay? We are—with our great natural advantages, our unbounded supply of coals and of all the useful metals, the energetic and never-tiring industry of our population, the enterprising spirit of our Anglo-Saxon blood, our peculiar climate which renders bodily and mental activity a condition of healthy existence, and our insular position, so pre-eminently favourable to commerce—we are, by these and other great natural advantages, and for an indefinite term must continue to be, the great manufacturing and mercantile nation of the world. What, therefore, have we to fear? Not that other nations may grow rich, but that they may grow poor; *for poor countries must ever be poor customers to us.* Let our artisans ever remember this."

"What is the most significant feature of the Exhibition?" Indisputably the machinery, its beautiful structure, and the altered tone in relation to its bearing on human labour. This, you will acknowledge, is a step in the right direction, and its importance is equally recognized by the foreigner as by ourselves. Here and there, it is true, a lingering prejudice or so may be entertained, but it finds little countenance from the great bulk of our artisans. One and all of the more intelligent and really influential among that useful class of men are convinced that machinery is a powerful adjunct, and that the more perfect it becomes the more powerful is its agency, and, also, the more valuable its assistance to their manual labour.

We have frequently laboured to impress this great truth upon the minds of the working classes* ; and under trying circumstances too, therefore feel a more than ordinary pleasure at perceiving its recognition. We addressed the workmen employed on the French railways, whose hatred to machinery was evinced rather inconveniently on one or two occasions, in the following terms, which may not be inappropriately applied to the present time :—

"What is a machine? A contrivance by man to increase his power over matter. If the power of man, then, to subdue matter be a good, which, we presume, no one will deny, the increase of that power must be a greater good, and its ultimate perfection the greatest of all goods. The mind may conceive, as it frequently does, the grandest projects for human improvement, but the hand alone cannot execute them. There have been thousands of instances of this kind, which the world has never known, and which must have died away in the brain that conceived them. One of the great causes, if not the principal, of man's advancing so slowly in the path of amelioration, has been the incapacity of his hand to execute the conceptions of his head; it follows, therefore, that the nearer the power of the hand approximates to that of the head, the more rapid will be his advance.

"Man is the creature of machinery in a civilized state; deprive him of it and he instantly becomes helpless and unprotected. Man himself is a magnificent machine, and God, his creator, exclaims the pious and eloquent Barrow, is the first of *mechanicians*. Look at the form of man, either in repose or in activity, and you cannot but admire its beauty. What a majestic pile is that bony construction!—how ingeniously devised and how exquisitely formed!—how true in principle and how admirable in practice!

"Man, know thyself," says the Scripture, which may be interpreted, without the slightest irreverence, "contemplate thine own frame, examine its construction, and imitate its perfection, in thy works!" The nearer man, therefore, approaches to the perfection of his own frame in his mechanical contrivance, the nearer he approaches to divine wisdom. And without violating the implicit reverence which is due to the Creator, may we not imagine some superior spirit whispering in the ear of earth's first-born—"Man, make a machine, and your condition shall be improved, and the more perfect you get in machinery, the happier, the better, your state of existence, and the only possible way to obtain absolute dominion over the earth is by

* Vide "Machinery, is it a Good or an Evil." Paris, 1844.

mechanical perfection. There is one thing, however, very clear, that man *has* partially emancipated himself from his material slavery by his mechanical inventions; and when the spade first assisted the power of his hand, and the plough first followed the direction of his head, the beginning of his emancipation must practically have commenced."

Could the holy army of martyrs, who were literally hunted out of existence for displaying the inventive powers with which the Creator had endowed them, once more revisit their earthly habitations, how strange must be their sensations! William Lea here would see millions depending upon his stocking-frame for their daily bread, though he wandered from place to place with that sacred treasure, heart-broken and starving, without meeting with a single soul capable of recognizing its wondrous utility; and Hargraves would find some consolation for the bitterness of his existence in the fact of his invention being universally cherished and improved; nor would the delight of Jacquard be less could his spirit quietly contemplate the improvements of his loom, whereby the use of cards is altogether dispensed with. Poor Jacquard thought that he had attained all that was requisite, by the substitution of cards for the old cords and pedals; but were he to examine the loom now in the Exhibition—the first of the kind, and the invention of a Belgian—his benevolent heart would leap with delight. The ingenious Frenchman diminished the number of unsightly cripples by his comparatively easy process of weaving the fabric; and the Belgian, carrying improvement a step further, has greatly facilitated the power of production, by diminishing the complication and weight of labour. Thousands of other instances might be adduced, were we to enumerate, even partially, the progressive stages of improvement which one and all of the mechanical contributions to the Exhibition present. Each machine, in short, is little more than a *monument of mental martyrs.*

An old writer, whose name we have forgotten, pithily remarks, that "what is man's calamity in his ignorance, is his blessing in his intelligence." This remark may be applied, more or less, to the whole range of human actions, but to none more closely than to man's treatment of his mechanical inventions. Some few years ago, the bulk of artizans were much opposed to machinery, and did all they could to arrest its improvement. The machines they were in the habit of using were thought sufficiently perfect; and those that had the slightest tendency to interfere with them were uniformly condemned. They committed the logical absurdity of protecting *imperfection*, and of condemning *perfection.*

Happily for themselves, and for mankind at large, our artizans have become more enlightened, and view the rich treasure of mechanical skill in the Exhibition with feelings of almost affectionate admiration. Of all the changes in the industrial relations of the world we deem this the most important, therefore have considered it as the prominent feature of the Exhibition. Machinery, it will be found, is the true source of moral progress and industrial improvement.

Another feature equally deserving of notice, however, is the contributions of raw materials. As the latter compose the basis of all our manufactures, it is indispensable that we should form a correct judgment of their relative excellence, and not depend upon caprice or accident for our supplies. Hitherto this has been the case, for the merchant has made the latter dependant upon his exports, and not shaped his exports so as to bring back the best specimens of the raw material. For instance, we export a great quantity of manufactured articles to the Brazils, and to secure a return cargo our ships are laden, perhaps, with rosewood, although a finer quality of that material may be found elsewhere, which would prove highly advantageous to our cabinetmakers. The same remark is partially applicable to the bulk of raw materials, which materially retards the excellence of our general industry. The Exhibition has evoked from every quarter of the globe the finest specimens of its raw productions, and has afforded an opportunity of examining them "cheek by jowl,"—an opportunity of immense utility to the industrial interests of the country. The consumer now will not content himself with receiving comparatively bad timber from Canada, inferior bark from France, and mediocre linseed from Prussia; but as he ranges his eye round the Exhibition he will immediately detect the whereabouts of the finest qualities of each of these important articles. The same remark may be applied to the iron, the lead, the copper, the ores, the minerals, and, indeed, to the whole range of our contributions. If the Exhibition has effected only this good, it has amply repaid the time, the trouble, the anxiety, the expense, the annoyance, and every other *the*, that a disturbed imagination, a narrow judgment, and a malevolent disposition, could attach a disparaging and contemptuous epithet to. Taking even this microscopic view of the Crystal Palace we can discern sufficient materials for the commendation of those who have been more immediately instrumental in its erection, but this is a theme upon which we have no desire to dwell. Let it suffice that we recognise the Exhibition as *un fait accompli*, and shall treat it accordingly; and we can the better afford this, seeing that we were about the first in the field to

anticipate the benefits which have already accrued from it. "There is nothing succeeds like success," says the French proverb, and we have a lively recollection of the strange and gibberish notes that were rife in many quarters when the idea of the Crystal Palace was in embryo, which contrast somewhat strangely with the Io Peans now so lustily shouted in its favour. *N'importe;* we shall continue in the same strain, and simply repeat our thanks to the Prince, whose moral courage never for a moment flagged, and whose practical sagacity must have astonished even his friends. Every obstacle—and their name is legion—was quietly overcome by patient endurance and untiring perseverance, in spite of the cold discouragement of many, and the positive obstruction of the few.

One word more. In a somewhat hasty glance at the varied and valuable collection of objects, it is natural to suppose that many of a highly interesting nature must have escaped our notice. The following fact is an instance in point:—The American revolving pistol is noticed under its proper head, with a due acknowledgment of the originality of the invention, and its powers of destruction; but, since these observations were committed to type, we have derived some information which leads us to modify our first impressions. The originality of the invention is questionable,—it being a simple improvement upon a preceding production. Some thirty years ago the Messrs. Evans and Son, of Wardour Street, the eminent machinists, manufactured 200 revolving barrels, enclosing lesser barrels, exactly like the pistol in the Exhibition, and the only difference between the two inventions is simply this—the cylinder of the original was pressed back by the finger and thumb of the left hand, while the pistol revolves by means of a click after each discharge. In almost every other respect the productions are the same. It is somewhat singular that the order was given to Messrs. Evans and Son by a Mr. Collyer, an American; and if he were the inventor of the revolving barrel, it is equally creditable to the ingenuity of our transatlantic brethren.

In presenting the second edition of the "Wealth of the World in its Workshops" to the reader, we have simply to remark that the illustration of the useful rather than the ornamental, in industrial art, has been our principal aim, believing with Milton that—

> " . . . . that which before us lies
> In daily life is the prime wisdom,"

# PRODUCTIONS IN METALS.

## CHAPTER I.—STEEL.

The art of making steel of the finest quality is almost exclusively confined to this country. In France and in Germany the theory has been studied with the utmost attention, but, whether it be deficiency of means or inferior chemical knowledge of this particular material, or both combined, the fact still remains: the practical skill of neither of these countries is equal to our own.

Steel is a combination of iron and carbon in certain proportions. Cast iron is more highly charged with carbon than steel; while bar-iron, being deprived of the carbon it contained in a pig-state, by the process of puddling and rolling, must be recharged before it can be made into steel. This is done by what, at Sheffield, is called "cementing." Bar-iron, mostly Swedish and Russian, is there charged with carbon until it becomes steel, and by hammering and rolling, is refined and brought to the desired state of perfection. Hence, there are two processes resorted to, that of decarbonizing to make bar-iron, and that of recharging or cementing, to restore the carbon. Steel, therefore, occupies a middle place between malleable iron and cast iron; but its qualities are different from either, depending, in a great measure, on the manner in which the two combine. Sometimes the combination presents a granulated texture, sometimes fibrous, sometimes smooth and glittering, at other times it is rough and dull. How these changes take place is still a mystery, even to practical and scientific observers. It will suffice, for our purpose, to state that all our steel is made from bar-iron, which has been previously made from the ore, and that the change from iron to steel is effected by a series of processes which we shall now briefly detail.

Sheffield is the principal seat of the manufacture of steel, as Manchester is of cottons and Leeds of woollens. In that busy town there are several establishments where the iron is converted into steel; some of these are called "tilts," others "mills," and others

again "converting-works," while a few combine all the operations within themselves. Some manufacturers are entirely occupied in *converting*, or making the crudest form of steel; others in *tilting*, or giving a further development to it; others in *casting*, which is an advanced stage of the metal, being poured into ingots or moulds in a liquid state; and others in *milling* or *rolling*, which shapes the steel either into bars or sheets; and, in a few instances, all these operations are performed in a single establishment. The "converting," or first process, is as follows:—The bars of iron, cut to a particular length, are packed or piled up in the furnace, which somewhat resembles a glass-house, having a conical covering to the oven. There are two oblong troughs in the oven, each measuring about twenty feet in length, a yard deep, and the same in width, and so placed that a strong body of flame, by playing round both of them, may augment the heat within. On the bottom of each trough is spread a layer of coarsely powdered charcoal, then a layer of iron bars, side by side, as many as the width will admit; then another layer of charcoal, then a layer of iron, and so on till the trough is filled, which contains about thirty alternations of charcoal and iron. The surface is covered with a clayey substance called *wheelswarf*, made into a kind of cement, obtained from the abrasion of the grindstones used at Sheffield. A coal fire is then kindled, and kept up fiercely for several days, during which time the iron is in a red-hot, or, white-heat, state; the charcoal also becomes highly heated, being covered with a coating of wheelswarf, so that the iron gradually absorbs a portion of it. The workmen, from long practice, can easily test the progress of the operation, which requires to be carefully watched, as the subsequent application of the metal is mainly decided by it. Steel intended for coach-springs, for instance, requires a comparatively low degree of heat, but for several articles of manufacture it requires a higher degree of conversion; that which is subsequently "sheared" or hammered for knife-blades and other purposes, still higher; for files a yet higher conversion is necessary; and steel to be cast in a fluid state, requires the highest of all. It will easily be inferred that great nicety of observation is necessary through all these processes of conversion.

The blister-steel absorbs about one per cent. of carbon, and is seldom used in this state, except for coarse goods; it is called *common steel* when it has undergone a good hammering, after being reheated, which imparts to it a tougher quality. The next process is *shearing*, which consists in heating several pieces and hammering them

together, until a single mass is formed, which becomes more dense and tougher than the blister-steel from which it is made. The bars of blister-steel are broken into pieces of a foot long, which are heated in a furnace until they attain a white heat, then they are placed under a large tilt-hammer, which beats them out to thirty inches in length. To change these pieces into shear-steel, half a dozen of them are put one upon another in a pile, and firmly fixed at one end in a groove: this pile is placed in a furnace to *soak*, or to become partially heated. The group is then transferred to another furnace, where it is brought to a white heat. Great nicety is required in these several operations. When sufficiently heated it is submitted to a *shear* hammer, where it receives a beating on all four sides until it becomes thoroughly homogeneous, and assumes the form of a bar of steel two or three inches square. In some instances the operations are carried still further, the bar being cut in two, reheated and rewelded, and, according to the degree to which it is welded or sheared, the steel is called "double-shear," "single-shear," or "half-shear." The shear-steel made by this process loses all the flaws and blisters which distinguished it as blister-steel; it also acquires an evenness of surface throughout, and is more malleable and tenacious than it was before.

We now come to *cast-steel*, which perhaps is the most important process of all, as the beauty of steel manufactured articles are mainly dependent upon it. The heat required to melt steel is very intense, the furnaces, crucibles, and other apparatus used in the process, must therefore be so formed as to endure it. The crucibles are made of Stourbridge clay, carefully prepared for that purpose; they are rather less than two feet in height, and have a kind of sugar-loaf shape, each weighing about twenty-six pounds before it is annealed and thoroughly prepared for use. Before the crucibles are filled with metal they are placed in the furnace, where they remain until they become sufficiently durable for three successive meltings of four hours each. Each furnace, in which the crucibles are arranged side by side, is supplied with a certain quantity of coke, and, after a little time, more coke is thrown in, until it entirely surrounds them both. They are left in the furnace until they attain a white heat, when the cover of the latter is removed, and a long funnel let down into each pot, having its open end at a convenient height above. The steel, broken into fragments, is thrown through the funnel into the crucibles, which hold about forty pounds each of the metal. The crucibles are then closed, and occasionally watched during the melting process, more coke being added when necessary, and there being generally from four

to five tons of coke used in melting one ton of steel. The moulds, into which the molten metal is poured, are shaped so as to give oblong bars or ingots weighing from thirty-six to two hundred pounds each, according as they are wanted. Each mould is divided into two halves, which are bound closely together when the casting is about to take place, previous to which they are coated inside with an oily composition, and placed vertically in a hole of the cast-house, with the upper end open. The metal is then poured in, which is an arduous task for the workmen, the heat being so intense, especially in the furnace whence it is drawn. This process is repeated thrice in one day, when the crucible is no longer fit for use. Changes in the process of melting steel have taken place during the last few years, each manufacturer trying experiments of his own. For instance, it was conjectured that Swedish iron derived some of its valuable properties from the presence of a small portion of manganese, hence the latter has been introduced to the melting-pot, in order to improve the quality of cast-steel, or, in other terms, to make it more workable for certain articles of cutlery. If the cast-steel be for the purpose of making saws, the ingots are rather flat, so as to be conveniently rolled into sheets; but for other purposes, they are generally about as thick as they are wide.

The *tilting* of steel is another process. The object is to close the pores of the metal and to render it as dense as possible. All steel applied to the manufacture of the best articles is tilted, whether it be "shear" or "cast," which is effected thus:—The workmen are seated in suspended cradles in the tilt-house before the tilt-hammer, holding the bars of steel to be tilted, as they can move their bodies to and fro more easily, by paddling along with their feet, than if they stood or walked. The bars of steel are heated to a certain temperature, and are brought under the action of the hammer as described, which exposes every part to the blow of the instrument in an equable manner.

Let us now turn to the continental process of making steel, about which a great deal has been recently said, especially since the opening of the Exhibition, which contains one or two singular specimens of the manufacture. At Loh, near Müsen, on the Sieg, the process of making raw-steel is carried on to a considerable extent. The large slabs which are run from the furnace are broken into pieces, and a lump of about eight cwt. is heated by lying on the coals of the furnace used for puddling or decarbonizing. This is a low open furnace, containing a bed of charcoal about two and a half feet in depth and four feet square. The lump is plunged into the middle of the bed,

and exposed to the action of a blast until it comes to a melting state; and the puddler's art consists in so regulating the blast that no more carbon shall be extracted than is necessary, by checking the fusion at the precise moment. The lump is frequently brought under a heavy hammer, when it is shaped to a peculiar form and cut into four pieces. Each of these pieces, after being reheated several times, is reduced to a bar an inch and a half square, the temper of which is tried by breaking off the end with a blow on an horizontal bar. If it breaks short off, and the core is perfect, it is reckoned to be a good article; on the contrary, if a black core is generated, either from burnt metal or from extraneous matter that has not been expelled under the hammer, it is thrown aside as inferior metal. The analysis of the raw steel bars shows that they contain about two per cent. of carbon,—nearly double the quantity that English cast-steel contains; so that by "shearing" or welding together strips of this steel with strips of bar-iron, under heavy hammers, or by means of casting with a proportion of malleable iron, the infusion of carbon is obtained, and what is called steel is produced.

The Messrs. Hundsdecker, whose works are near Altena on the Sieg, manufacture steel principally in this way. The iron-ore which is most abundant in the Sieg district, is of a steelly nature, and may be denominated a carburetted protoxide of iron. When puddled with charcoal, according to the custom of the country, what is called steel is made from it without any cementing process. This may be called steel-pig, which, when mixed with a due proportion of bar-iron, produces what is called cast-steel. At Burg, near Solingen, scissors and other implements of low quality are cast and turned out malleable by the simple process of uniting the pig with bar-iron in due proportions.

And this leads us naturally to advert to the large lump of metal which M. Krupp, of Essen, has contributed to the Exhibition, and which he designates cast-steel. It may be so in the Prussian sense of the term, but not, assuredly, in the Sheffield sense. The practical manufacturers of the latter city would call it a bar, or lump, of cast and wrought iron, mixed in due proportions, the latter having gone through the process of puddling. The only thing, therefore, that entitles it to the name of *steel* is, that a certain, and we apprehend a small, portion of the lump has gone through the first process towards becoming steel; but to compare it, in its compact mass, with the finished production which we call steel, and which has gone through such a variety of trying, improving, and refining processes that are

invariably adopted at Sheffield, in the manufacture of that metal, would be truly ridiculous, to speak in the most moderate terms.

The proportion of sulphur that is imbibed by all iron smelted with coke is what makes English bar-iron inferior to Swedish or Russian: hence we are compelled to use the latter for the manufacture of steel. Some of the Russian iron is equal to the Swedish, and a great number of experiments have been made in Germany during the last ten or fifteen years, especially in the Rhenish districts, to find a shorter and cheaper mode than the ordinary one for turning iron into steel. In some instances, these experiments have turned out highly useful, though they have not yet resulted in placing the conversion of the general qualities of the metal upon anything like a sound and systematic basis. In favour of one of the experiments may be cited the files of Solingen, which were in considerable demand some few years ago, from their tough and elastic qualities; but the Sheffield file is now much preferred, and where quality is a desideratum, it invariably supersedes its once German rival. For fine cutlery the highly finished steel of Sheffield is still imported into Germany, and it has been found hitherto impossible to make a chisel of the German steel that will cut iron like an English chisel. Files are likewise imported from Sheffield into Germany; while sugar-knives, or matchets, and wood-cutter's implements for rough and pioneering work, are still in demand at Solingen.

We have traced the manufacture of steel from the rude ore up to the state when it is ready for conversion into general use; but it would occupy too large a space to describe the different processes to which the metal is subjected before it assumes either of the forms indicating its finished state. Let it suffice that we describe the manufacture of a razor, one of the most difficult articles to finish properly that comes under the workman's hands.

The blade of a razor is forged from steel of a peculiar quality. The rod of steel is heated at one end, and hammered into a shape bearing a rude resemblance to that of a razor. The concavity of the surface is produced by hammering the blade on the rounded edge of an anvil. The piece is then cut off, with an additional length to form the *tang* for insertion in the handle. The quality of the metal is tested by the severe hammering which it necessarily receives before the edge becomes sufficiently fine and tapered from the back. Razors are generally tempered before they are ground; sometimes, however, they are ground before they are tempered. Very small stones are used for grinding; often those which have been worn

away to too small a size for other purposes. A razor ground upon a four-inch stone is considered as a test of its goodness, which may be thus explained:—Every razor is concave or hollow on the surface; this concavity must be produced or maintained in grinding by the use of a stone equally convex. When a stone four inches in diameter is employed, it must give to the razor a corresponding concavity, or a curve of two inches radius; and this can only be produced by wearing away the metal until a thin edge is gained, and the thinner the edge, the finer and sharper can it be made in the process of *whetting*. The inference is simply this, that other things being equal, a razor ground on a four-inch stone will yield a keener edge than one ground on a stone six, eight, or ten inches in diameter. The concavity of a razor, according to the grinding *savans* of Sheffield, ought to bear some relation to the kind of beard with which it is to be brought in contact. Thus, a strong, wiry beard, requires a razor whose edge possesses strength as well as keenness, and the latter ought, therefore, to be ground on a stone larger than four inches in diameter. Such a beard would spoil a very fine and delicately-edged razor. The tempering of a razor is not less important than the grinding, since the fineness and durability of the edge greatly depend upon it. This tempering is given by exposing the article to a certain temperature, and then allowing it to cool gradually; the particular temperature chosen being a matter of experience. There is no known principle to test the temper of a razor, each workman depending upon his own experience; and the *colour* of the steel when hot is generally taken as the test, each kind of cutlery having a colour best fitted for itself. The razor, when ground, tempered, and polished, is fitted into its handle, which is an ordinary and simple process.

The metalliferous contributions to the Exhibition are, as was to be expected, various and diversified. The continent has done its best, doubtless, to maintain its preceding reputation, both in the crude and in the most finished condition of the metals. Sweden, whose name is suggestive of iron, has furnished several specimens of her productive power, from the rough ore in its natural state, up to the stamped bar ready for the steeling process of Sheffield. To the geologist, as well as to the practical mind, this contribution must prove equally interesting and instructive. In the Zollverein, we have a large assortment of metal-work in a manufactured state, principally tools and instruments used in the ordinary occupations of the working-man. The Messrs. Ditmar, of Wurtemberg, have furnished a great variety of the latter, several of which vary in their construction from similar tools in this

country, the saws especially; it will be for the practical man to appreciate the merit of the variation, while as regards the finish and quality, it requires but little experience to note their inferiority when compared to the productions of Sheffield. M. Fischer, of Hainfield, has contributed his excellence in the manufacture of files to perplex the eye of even the initiated, and in many of their surface-forms they are singularly different to our manufacture; still, according to practical experience, after the severest of all trials, they are considered much inferior to ours, both in hardness and elastic durability.

The cutlery, throughout the foreign departments, especially the "Steyer" (Austria), is well worth examining, if it be simply to note down the different means which different minds adopt to attain the same end; as to the intrinsic quality of the productions, the beauty of their finish, or their adaptability to their several purposes, with few exceptions, there cannot be a moment's consideration about the matter—Sheffield is so much a-head in almost every respect.

The designs of several of the stoves in the foreign contributions may be studied with advantage, especially that of M. Banns, of Cobourg, which is alike novel and ingenious in construction; but, as regards the quantity of fuel it is likely to consume, or the relative heat it can impart to the room in which it may be fixed, we can only form a faint conjecture at the most. The Vieille Montagne Company, in addition to their large statue of the Queen, occupying a prominent position in the eastern nave, have contributed specimens of zinc-sheet work; and the reputation which the company has acquired will ensure for its productions a minute and careful examination. Their supremacy however, in the manufacture of zinc has been some time on the decline, and even their equality is now threatened by the contributions from one or two of our manufacturers of that metal.

We now turn more immediately to the steel articles in the Exhibition of the English manufacturers, many of them making an effective display. Among the most interesting contributions must be ranked that of Messrs. Johnson, Cammell, & Co.,* of the Cyclop Works, Sheffield, at least to the practical mind. Here we have specimens of the different processes of making steel, from the imported iron up to the most refined state of the metal; and, also, of manufactured articles in which the best quality of steel is an indispensable requisite. Follow that piece of iron through all its various stages—carbonized, converted, melted, and re-

* This enterprising firm were the inventors of the well known cast-steel springs, and by their skilful manipulation of the metal have vastly enlarged its consumption and improved the general manufacture of steel.

fined—until it terminates in one of the laminæ of those highly-finished coach-springs, and you have a lesson in manufacturing art few of which can be more useful and instructive. Then let your mind range over the fabrication of the metal—in Prussia, for instance, and trace in imagination the progressive stages of a similar piece of the raw material in the foundries of that country, described in a preceding page, and you will instantly recognize the cause of our superiority in the manufacture of steel. Indeed, the metal of Prussia, in its most finished state, is scarcely worthy the name of steel, not having passed through the cementing ordeal to which it is subjected in England, The steel of the above firm has acquired, we believe, a high name for its quality, whether it be in the condition of "cemented blister," "double-refined cast," "double shear," or "elastic-spring," all of which enter largely into the general purposes of manufacture. In locomotive mechanical aids, such as springs, files, &c., &c., they make an interesting display; the "curvilinear tanged file," for instance, being a great improvement upon the common forms of that tool, for certain purposes; so, also, is the "continuous tooth concave and convex file," which received the recognition of a medal from the Society of Arts. In instruments such as these are to be traced the latent principle of progress; they not only simplify, but greatly diminish, the amount of labour. In mentioning one firm of real practical eminence, we mention, as it were, all that come within the range of their peculiar class of manufacture; therefore, by way of limiting our labours, we shall direct attention to the files of Johnson Cammell & Co., whose careful finish will be immediately recognized, to their springs for railway-carriages, and, above all, to their piston-rod, weighing 16 cwt., the finest and largest piece of steel in the Exhibition. This rod is of cast steel, and has passed through the several processes of manufacture already enumerated; and, as regards its working qualities, it is fair to assume that they are far more efficient than those of the ordinary pistons, which are generally made of greatly inferior metal. These, we believe, are the main points in which we are superior to the continent in the manufacture of steel, and truly important they are in every sense. The Messrs. Rogers occupy a large space in the western nave, with a case containing 230 pairs of scissors, of different sizes and patterns. The beauty and ornamentation of these productions attest the excellence we have attained in cutlery; and their quality, according to general repute, is fully equal to their ornamentation. The process of manufacturing the scissor is also exhibited throughout its ten different stages, which is highly

interesting to the uninitiated in such matters. The monster and miniature knives, with their numerous blades, are curiosities in their way—wondrous feats in mechanical and manipulative skill—and will, at least, have the effect of making many a little boy wish that he was the fortunate possessor of them. The lilliputian razors, we presume, are simply made to display the ingenuity of our workmen, and, as such, are marvellous curiosities. Naylor, Vickers, and Co. have a large display of rods, bars, &c., of steel, which exhibit the general excellence of their work, and contribute effectually to the Exhibition; so also have Spear and Jackson, in sending their series of saws, for which they are deservedly celebrated. The cast-steel circular saw, five feet in diameter, is a fine piece of metallic work. Equally attractive to the cutler is the large saw of Joseph Peace & Co.; the quality, however, can only be tested by use, steel in a manufactured state so frequently deceiving the eye of even practical experience. There are, likewise, a few other articles in the contribution of the latter firm well deserving of attention. Messrs. Unwin and Rogers have contributed an excellent display of pistol-knives, spring-knives, &c., for which they are generally considered unsurpassed; and their surgical instruments are equally entitled to remark, from their fine quality and finish. There are several other exhibitors, whose specimens are entitled to the minutest and most careful examination, and will amply repay the time bestowed upon them.

Turning to another branch of metal-work, grates, we have a rich and varied display, which far excels the foreign contributions in all respects, if we, perhaps, except one or two instances where the design may be a little a-head of us. In the beauty of the material, in the truthful finish of the work, and, apparently, in the enduring qualities of the article, there can be no question of our marked superiority; and, as regards price, we are equally on the fortunate side, as the foreigner cannot compete with us on the ground of economy in objects of iron and steel work. The Coalbrook Dale Company have made a grand display of their peculiar excellence in the manufacture of grates; so have Yates, Haywood, & Co., besides other ironworks equally calculated to arrest the attention. Jobson has two very handsome grates, with more pretension to excellence than the majority of others, in regard to the isolated position in which they are placed; nevertheless, they are highly finished productions, and are an ornament to the Exhibition. Feetham & Co., in our humble opinion, have contributed the most stylish grates, both in design and in ornamentation, and, as regards workmanship, they have no superior; while Rippon & Burton

have furnished, perhaps, the most effective and economical specimen. Their "Nautilus Grate" is one of the most compact and simply constructed objects we have yet seen, and is highly deserving of careful examination. In the display of useful domestic articles, and even of those of higher pretension, Messrs. Maplebeck & Lowe are peculiarly conspicuous; not so much in the quantity as in the peculiar uses to which their comparatively few objects are adapted. The agricultural implements of this firm are also a highly creditable contribution; and the "Improved Door Fittings," from their appearance, are likely to become generally useful. Messrs. Benetfink & Jones have a creditable display, but not so numerous and attractive as several around them, in appearance at least; still they exhibit one or two objects which fully entitle them to a distinct notice. Messrs. Cocker & Sons exhibit their peculiar make of cast-steel needles, from the wire up to their finished state, and an interesting exhibition it is: this firm, we believe, were the first to alleviate the condition of the "dry grinders" in their destructive occupation, by constructing a powerful fan underneath the stone of the pointer, which draws down the dust and particles into a pipe, leaving the atmosphere of the room perfectly clear, so that a "dry grinder" can now pursue his occupation as healthily as others engaged in needle-making. Chubb makes a fine display of locks, manufactured in the most perfect manner: nor must we omit to note the case of locks of massive and bold workmanship, exhibited by Messrs. Bramah and Son. It is really quite a treat to observe the excellent workmanship and high finish which they one and all exhibit. In another important branch of manufacture, where excellence of work is equally exhibited, we have some good specimens—we allude to screws. At one time we fell off in the manufacture of screws, from the apathy of some of our manufacturers, but the trade is again returning to Birmingham, through the energy of one or two spirited individuals. America was compelled, in self-defence, as it were, to make the great bulk of the screws she required; but since we have improved, both in the quality of the metal and the work, she finds it more advantageous to purchase her supplies here. Messrs. Henn & Bradley have supplied a good assortment of their peculiarly effective make—"The Crown-Tapered Screw." Formerly, the screw in general use was as thick at the end as at the base, which had a tendency to splinter and break the wood when inserted in it, and several houses even now still make them on the old plan. The old-fashioned screw, however, does not bite so closely as the taper screw, which gradually insinuates itself, and becomes as

firm and fixed as though it were part of the material in which it is inserted. Henn and Bradley have wrought a great change in the application of screws, exhibiting specimens of the most delicate structure for pianofortes, and also those for the heaviest railway purposes.

In the foreign contributions there are one or two objects that we have omitted to call attention to. F. Krupp of Essen, one of the most intelligent and successful manufacturers in Prussia, exhibits the piece of rolled metal to which we have already alluded. Also a rolling-mill, which is represented to have the rollers of an equal hardness throughout; consequently, the pressure upon the metal rolled must be equal, a great desideratum, which is attainable more by accident than by design. The mass of "forged cast-steel," as it is called, may be as tough as alleged; if it be, our manufacturers at Sheffield are bestowing a great deal of unnecessary labour upon their tough steel, seeing with how little labour, comparatively, that lump has been produced. The mounted cannon is a specimen of highly-finished mechanism; the metal has been first cast, then bored, and finally polished. The polished rollers just below it are a fine specimen of the exquisite surface which may be obtained on steel by certain processes, which, however, are known here as well as abroad.

In the Belgian department there are some fine specimens of razors, which, for ornament and polish, appear fully equal to our own, but as the proof of the pudding is in the eating, according to the proverb, so the fact of the foreigner imposing high duties upon the importation of our steel goods, and, in some instances, entirely prohibiting them, is the best proof of their superior quality.

## CHAPTER II.—SWORDS, GUNS, AND PISTOLS.

In the manufacture of swords we still excel the foreigner, although Solingen has advanced somewhat rapidly upon us within the last few years or so; but, if due regard be paid to quality as well as to price, Birmingham has no equal on the continent. The same remark will apply to other military weapons. True, the trade in muskets has migrated to Belgium, so has that of common fowling-pieces, both branches within these few years affording almost constant employment to thousands of hands in and around Birmingham; and the same observation will apply to swords, the manufacture of which has taken its flight to Solingen, where they can be produced, we presume,

cheaper and of a more sightly and taking condition than in this country. This, however, is a point well deserving the attention of our manufacturers, as it naturally suggests some grave reflections as regards the future. Let any one walk through the town of Liege, and mark attentively the nature of the predominant industry of that city; he will not be long there before he descries its presence, a quantity of muskets, in every stage of manufacture, being constantly intruded before his eyes. Liege has become the Birmingham of the world, at least for muskets. Whence has arisen this change? Most of the continental manufacturers aim at cheapness, with the view of supplying the demand which more or less exists among the semi-civilised portions of mankind, and consider the high finish, the goodness of workmanship, and the effective quality of the instrument, but of minor importance. Birmingham, on the contrary, prides herself upon the excellent character of her work; and perhaps there is no branch of industry in which a larger amount of mechanical skill is displayed than in the manufacture of military weapons. One or two causes may be assigned for the diminution of employment in this branch of industry. First, the decrease of wars, so that orders are only given on great emergencies, such as the *coup d'etat* of M. Thiers in 1840, which imparted a sudden gush to the manufacture of Birmingham; at other times, the continental governments supply themselves from their own manufactures, which have sprung up in almost every state since the peace of 1815. The only demand, therefore, is from North and South America, Brazil, Mexico, &c., which are principally supplied by Solingen and Belgium, who copy our patterns, and manufacture an inferior article. Secondly, there is the *proof* required in this country, which necessarily compels the manufacturer to use a certain weight of metal, while the foreigner, on the contrary, has no such restriction imposed on his productive power: hence he can produce cheaper. We are not attempting to decry the *proof* of a gun, believing it to be a humane provision, and one which ought to be exacted of every manufacturer of fire-arms, but simply cite it as one of the causes of the decline of our manufacture. Again, the fabrication of swords by the English government has somewhat diminished the trade in that weapon; and the custom of officers, on state occasions, using their ordinary field swords, has given an additional blow to the highest class of productions. We shall somewhat minutely describe the process of this interesting manufacture.

The preparation of the steel for swords is a matter of great importance, which may readily be inferred when we state that the value

of the metal varies from £25 to £85 per ton. Suppose a mould of steel of sufficient length, when cut in two, to make a couple of blades. These are called sword-moulds. The flutes, or creases, on the back of the blade are formed in the process of hammering, by means of variously-shaped pieces of steel, fastened to the anvil and curved, or fitted, into a gauge which corresponds to the indentation to be made. The process of *hardening* succeeds, which is accomplished by heating the metal gradually, and by immersing it in water. It is then tempered, or brought back to a straw-colour, tested by striking it on the back and edge against a wooden block, and if the blade stands this test, it is handed to the grinder, who speedily removes, with his large stone, all the irregularities of the hammering on its surface. The dexterity of hand required before it is transferred to the grinder, is one of the most noticeable features in sword-making, as some workmen make little or no waste, whilst others spoil no inconsiderable portion of the blades they temper. To clean the grooves, stones with raised beads are used; then follows glazing, on what are called "bobs" of wood, with emery and glue; and, finally, the process of polishing is effected by a series of wheels, or "bobs," with fine emery and oil. The brilliant polish is obtained by powdered ironstone, or crocus. The hilts of the best swords are forged out of steel, but most of the inferior makers get them cast from malleable iron, and to give them the appearance of steel they are submitted to a process which makes them brittle, and comparatively unserviceable. This process, however, enables certain houses to supply the present regulation swords for light and heavy cavalry at very low prices, as there is a saving of at least sixty-five per cent. when compared to the forged or wrought method of making the hilts. The latter are modelled in wax before they are cast, which is a somewhat expensive item in a first-class sword-making establishment. The important qualities in a sword are—length of blade, strength and firmness, combined with lightness, elasticity and easy balance, which make it readily wieldable, all of which are mainly dependent upon its tempering. The clearness of the steel, its freedom from blacks and flaws, or cracks, is likewise a desideratum; and lastly, its high finish and ornamentation. Some of the hilts are elaborately worked out of solid steel, requiring a great deal of labour. A piece of cast-steel is drilled in holes as small as a pin's point, the latter being filed out bit by bit into shapes which ultimately form the pattern. This kind of work is occasionally so minute that a workman has been employed on a single hilt for three months at a stretch.

Of course, our remarks have reference exclusively to the highest class of sword-makers, such as Reeves, Grieves, & Co., who employ the best hands and turn out the best work; just as much so as Westley Richards, or Tipping and Lawden, do in the manufacture of guns.

The much-vaunted Damascus blade is inferior to the best made English, at least if tested by the qualities required in a good sword—clearness of surface, length and strength, elasticity and lightness. In fact, the Damascus blade is unfit for the general use of the British soldier, being too much curved, and too heavy for the exercise to which the latter is subjected. The only excellence of a Damascus blade consists in the granular structure of the steel, which certainly adds to its beauty, if not to its effectiveness. These blades, moreover, are seldom elastic, and, when tested like the English, are little better than iron; besides, experience has shown that an English cast-steel blade, of the same weight and shape, will cut them to pieces with the greatest ease; nevertheless the prestige is in their favour, and many an Englishman, accustomed to wear a sword, will give from £20 to £50 for a Damascus blade, while he almost grudges 50 or 60 shillings for a superior one of English make.

The ornamentation of swords is a peculiar art. What is called *Damascening*, or introducing precious metals, consists in making an incision in the surface of the blade, and introducing by pressure threads of gold and silver. This process is capable of displaying the taste of the artizan, and was eagerly adopted by the sword-cutlers of the middle ages. Etching, another mode of ornamentation, is effected by covering the blade with a ground, upon which a design is cut, when, an acid being applied and the ground removed, the design is found on the weapon quite perfect. Steel sheaths are made by bending thin plates round a mandril, after which they are soldered, ground, and ultimately polished.

Turning to the Exhibition, we are brought at once into immediate contact with the Toledo manufacture of blades, so famous throughout the world for their elastic properties. "The flexibility," says Inglis, speaking of the Toledo make, "and excellent temper of the blades are surprising. There are two trials which every blade must undergo before it is pronounced sound—the trial of flexibility and the trial of temper. In the former it is thrust against a plate in the wall, and bent into an arc at least three parts of a circle; in the second it is struck edgeways upon a leaden table, with the whole force which can be given by a powerful man holding it with both hands." The blow is diminished about one third by holding the weapon with

both hands; the object being to strike evenly, so that all parts of the blade should be equally affected, which never can be the case when wielded by one hand. This is no very extraordinary proof of the elasticity of the Toledo blade. Take our method of testing a blade, which is much more severe—metal against metal: a stout cavalry sabre, for example, which contains about three times the weight of metal that a fine Toledo does. The point is placed against a pin in a board, and the blade bent round a curve formed by six or eight pins placed equidistant in the board; the degree of flexure being such that the middle of the sword deviates seven or eight inches from a straight line drawn from heel to point. It is then pressed down with its point on a board, and bent round or back to a prescribed distance. It is lastly struck, with all the force a man can use, against a stout wooden block, the edge, the back, and both sides, being struck in succession. When the sword has borne all these severe tests, it is declared fit for service.

The Spanish contribution, in fact, is simply a collection of rare and scattered curiosities, which doubtless have been made at Toledo, or elsewhere in Spain, but at an enormous cost of time and labour, and ought not to be considered as fair samples of their present manufacture. Almost every sword-cutler of that country has one of these *raræ aves* dangling in his workshop or in his house, and were you to place any credence in their magniloquent stories, you must conclude that they are the finest sword-makers in the world. The reverse is known to be the case, as every practical and unprejudiced mind will allow. These Toledo blades are sometimes undulated like a serpent, when unsheathed; but in the scabbard, they are almost bent to a circle. There can be no question about the temper of the steel, which can be as easily attained in this country, and indeed much easier than in Spain, and all we want to guard against is the notion that Spain excels us in the delicate manipulation of that metal. The pistols in the same case may be dismissed with a similar remark; they simply indicate that the Spaniards once possessed a knowledge of the highest branches of the manipulative art, and that it has long departed from them. The swords in the Russian department, although few, appear to be highly finished, both in polish and in ornamentation, and one or two specimens in the Zollverein indicate clearly that the Continent has paid considerable attention to this branch of manufacture. With the exception of Reeves and Grieves, R. Mole, and one or two others of trifling importance, there are but few contributions of our manufacture to the Exhibition; but it is evident to the practised eye

that we have little to fear from our neighbours on this head, apart from the circumstances already enlarged upon. In quality of metal, in ornamentation, and in all the really essential qualities of a sword, we occupy very high ground; in other respects we must yield to the foreigner.

We have already remarked that the manufacture of muskets and common fowling-pieces has migrated, in a great measure, to Belgium. But the better kind of work is still retained in this country, Birmingham being the principal seat of its manufacture, while the metropolis engrosses a certain portion of the finishing process, from its superior skill and workmanship.

There is no such thing as a gun-maker, properly speaking, each establishment confining itself to the production of parts only of a gun; so that the latter has to pass through a series of independent hands before it assumes a finished form. The most important part of a gun is the barrel, and the manufacture of this involves larger arrangements than any other part. These barrels are of two kinds, plain and twisted; the latter being the best and most expensive. Imagine, reader, heaps of old horse-nails, used-up coach-springs, and other fragments of well-seasoned iron, all jumbled together and thrown into the forge, where it remains until it is melted. The "puddler" then places a portion of the molten metal under an enormous hammer worked by steam, where it receives a welding that renders it hard, strong, and tough. It is now in the form of a thick sheet, which is cut into strips sufficient for the barrels. This strip, called a "skelp," is heated at the thicker end in a fire, placed upon a hollow groove in an anvil, and hammered so as to turn up the two edges, thereby giving it a concave form. A mandril is inserted in this cavity, and the hammerman dextrously beats up the iron round this mandril until it becomes a tube. The mandril being withdrawn, the iron is again heated to a welding temperature, and hammered until the two edges become firmly united, the whole length of the "skelp" being gradually and successively treated in the same way. A twisted barrel is brought to the tubular form in a very curious way. The iron is cut to the shape of very long narrow strips; and one end of a strip being fastened to a rotating mandril, the whole is turned round the latter in a spiral form, exactly like a spiral spring. This spiral is taken off the mandril, heated, and hammered in such a way that all the edges weld and close together, forming a continuous tube. The tube is now course and rough, both within and without; and to impart the necessary evenness to the inside, it is scooped and scraped with a rod of iron, until it is perfectly cylindrical and smooth. The exterior is then

ground by large rough stones; sometimes it is turned by cutting tools, as in other kinds of turning. The barrel is now ready for the "proof," where it is conveyed, and loaded with a charge about five times greater than it will have to carry in actual use. If it prove defective, the proof-man marks it with a piece of chalk, indicating the part to be re-forged. The next process is cleaning and finishing, after which the "stocker" takes it in hand. He makes the stock, or wood work, generally of walnut-wood, which is cut to the required form by saws, planes, &c., when the "putter-together" fixes the barrel into it by means of screws. The bronzing, polishing, &c., is another department. The gun is now in a complete state. The majority of locks, it is necessary to remark, are made at Wolverhampton, their manufacture requiring a nicety of touch and finish which the better sort of smiths alone can give. A word or two on steel-barrels, about which a great deal has been recently said, in consequence of the explosion at Battersea Fields. First, the steel-barrels have not generally been made of sufficiently good metal, and, secondly, the practice of filing them down at the breech, after proof, to such a degree of fineness as fancy or fashion may dictate, has rendered them dangerous. Respecting the quality of the metal, we were informed by one of the first manufacturers at Birmingham that the general run of barrels are made, for the sake of economy, with steel worth about fivepence per pound, whereas the metal ought to be so prepared that it would be worth about twelvepence. There, in a great measure, lies the defect.

The manufacture of "Rifles" is also deserving of a word or two. The manufacture of this instrument is based upon the principle, that if the bullet can be made to spin round, or rotate on its axis while passing through the barrel, it will continue to worm its way through the air with more straightness of path than otherwise would be attained. The bullet from a gun will be projected straight forward, provided it passes equably through the barrel; but if, as is sometimes the case, it rubs more against one side of the barrel than the other, from being unevenly rammed in, it will be diverted from its right course, and curve round while passing through the air, so that the marksman misses his aim. To rectify this, the barrel of a rifle is grooved spirally on the inside, in order that the bullet, by winding along these grooves in its progress, may acquire a rotatory motion round its own axis, which afterwards prevents it from swerving either to one side or to the other. This rifling is effected by a spiral-cutting instrument, fixed on the end of a rod, to which a peculiar movement is given. The number of grooves in this spiral, the number of turns which each

makes in its course through the barrel, and the depth of the grooves, are all points determined on differently, according to practical opinions, the principle being the same in all.

Having indulged in this brief description of gun-making, &c., we shall now glance at the contents of the Exhibition. Where to begin is the difficulty, there being so rich and varied a contribution of fire-arms. Almost every name, of any repute in the gun-making art, has sent a specimen or two; one alone excepted, and that perhaps the greatest. We allude to Purday. We had rather, indeed, abstain from giving any opinion upon such a take-for-granted subject as judging of guns, rifles, or pistols; for who would follow the dictates of his eye, seeing that so much depends upon trial, the only safe test, as respects the intrinsic quality of such objects. Place a piece of print, or silk, or woollen, before a man of practical experience in such materials, and he will be able to form a pretty accurate opinion of their respective qualities by simply examining them, either by touch or sight, or by both combined; but hand him a gun, or rifle, from one of the contributions in the Exhibition, at the same time studiously concealing the name of the maker, and the chances are that he will be completely bewildered, however profound and practical he might consider himself in such matters. In short, as far as we are concerned, it will be nothing more nor less than a complete begging of the question respecting the relative merits of the fire-arms in the Exhibition; and we would humbly suggest that it must be so, more or less, with any one who presumes in so *à priori* a manner to judge of such objects. But, it will be said, surely we can obtain something approximating to a correct judgment in such matters. Granted. Nevertheless, with the best practical experience, the judgment given must be influenced rather by the antecedent reputation of the maker of the object, than by the intrinsic quality of the object *per se*. The easiest, and perhaps the safest solution of the problem will be, unfortunately for all unknown contributors,—given the maker's name, and such and such is the best made article.

We shall content ourselves, therefore, with simply enumerating the "celebrities" in the art of gun-making who have contributed to the Exposition, and leave the rest to the practical profundity of the jury chosen to decide upon the subject.

Westley Richards, of Birmingham, exhibits rifles, double tiger-guns, a punt gun, and pistols. Lancaster, of London, has a peculiar rifle with what he calls an "elliptic smooth bore, twisted or spirally inclined;" and Lang, his alliterative competitor, presents the whole

series of fire-arms, "guns, rifles, pistols, and revolvers." Tipping and Lawden have furnished specimens of the gun-making process, from the bunch of stub nails up to the fine polish in the barrel, by way, we presume, of teaching "the young idea how to *shoot*;" and Egg, influenced apparently by a similar feeling, has *hatched* expressly for the occasion, a "self-priming and double-barrel copper cap fowling piece." Manton and Son, a familiar name, determined not to be worsted in the contest, have sent "double guns, double rifle, and duelling pistols with apparatus." The latter is very suggestive—it seems to say: Come to my shop if you want to kill, or be killed, in a trice; and Witton and Daw, directing their killing-skill, apparently, into a really suitable direction, exhibit "rifles for India and Africa." The two-ounce rifle of these manufacturers would make Gordon Cumming's mouth water; so at least we should infer, from hearing the remarks of an American upon it. Then we have Hart, of Birmingham, illustrating nearly the whole process of the manufacture; in short, detailing, as it were, the "birth, parentage, and *edification*" of a fire-arm, with his "specimens of gun barrel manufacture in every state, from the old horse-nail stubs of earliest period to the latest improvements;" and Wilkinson and Son, of Pall-mall, determined, apparently not to be outrun, on the fire-arm educational course, have also carefully prepared their "illustrations of the manufacture of gun barrels," &c., &c. May the race, say we, be to the swift, and the battle to the strong, even in the excellence of gun-making. Amongst the foreign contributions, the "American Revolver" attracts the most attention, and deservedly so, according to the opinions of practical judges. There is an exact copy of it in the Belgian department, which seems equally well made, and rather smarter in appearance; of its destructive qualities, of course, we can say nothing, nor of its prototype, the American, except by report, which would appear to be based upon very good authority. The several guns, pistols, and rifles in the French and Belgian contributions, to say the least of them, appear highly finished; in every other respect silence is probably the best.

## CHAPTER III.—PERCUSSION CAPS.

In the fire-arm department of industry we ought not to omit the manufacture of percussion caps, which, though apparently insignifi-

cant, gives employment to a great number of hands, and requires no little skill to perfect it. The machinery in common use for making caps was the invention, principally, of Mr. Richard Walker, of Birmingham, himself the largest manufacturer of caps in this country. In some respects it is exceedingly simple; in others, complicated; in its general operation most effective. We have examined caps at this establishment fitted for every possible size and variety of fire-arms, from those used in the smallest nipple up to those required for instruments of the most destructive calibre. The average supply, from this manufacturer, to the two great consumers of caps—the Government and the East India Company—is about a ton a month; each ton containing about a million of caps. The process of manufacturing this destructive little instrument is as follows:—Suppose a strip of metal about four and a quarter inches wide, one-sixteenth of an inch thick, and about five hundred yards long. This strip is passed through an ingeniously-constructed machine, which cuts diagonally thirteen small crosses, or blanks, at a time, and drops them into a box below. The machine performs 140 revolutions in a minute, so that 570 blanks are struck in a second. This is the first stage of the manufacture of the cap. The machine, indeed, may be called self-feeding, for when the coil or ribbon of metal is once within its grasp, it never loses hold, until the whole length has its surface cut with the nicest precision. The blanks are then put, one by one, into a screw-press, worked by the hand, which gives them the form of a cap; and so dextrous are some of the hands (mostly women) engaged in this process, that they can make 15,000 caps per day. The caps are next cleaned, then primed with a detonating compound at the rate of twenty-one gross per minute; after this they are dipped in a simple machine containing a prepared solution, forty-two at a time, which renders the priming impervious to the moisture of the atmosphere. The cap is then taken to the heating-room, where great care is necessary to prevent explosion, then follows glazing, and lastly, a minute examination of each cap, when the manufacture is completed.

The exhibition of caps in the Great Building is comparatively insignificant. The French have sent a specimen of their manufacture, but they appear ragged and meagre compared to our own; there are, likewise, specimens in the Belgian department, which are as much superior to the French, as we are to the Belgians. Upon repeated trials neither of these manufactured caps will resist the damp or fire so certainly as the English; the best quality of the latter will stand a good soaking October shower, and yet fire effectually, whereas the

French will scarcely endure the slightest damp. We have known soldiers in the African army, who complained bitterly of the bad quality of the caps supplied to them by the French Commissariat, and have remarked that, after a night's dew, they had great difficulty in disharging their muskets. Many a poor fellow's life has depended upon the quality of his percussion cap.

The case of Richard Walker is decidedly the finest specimen of the English manufacture of caps; it contains almost every kind in use, and all appear to be well and substantially made. Joyce's contribution comes next, and, with the exception of another of no great promise, we believe that we have mentioned the whole. We have little to apprehend from the foreigner on this ground, although Belgium has greatly improved within the last five years, as we know from practical experience. A. and E. Holler, of Solingen, exhibit a curiously-deviced sword or two, some foils, and rapiers, and damask blades in the oriental style of ornamentation. The finish, workmanship, and apparent quality of the steel, are much to be preferred to those exhibited in the scissors, penknives, table cutlery, and razors of the same exhibitors; but in neither one nor the other do they equal the respective productions of this country. A. Mannesmann, of Remscheid, exhibits a great variety of files, screws, and steel in its several forms or states; but there is nothing beyond the ordinary character of manufacture in their appearance. L. Sauerbrey, of Gotha, has contributed a somewhat singular fire-arm—a double rifle of solid cast steel. The barrels are bored in a converging direction, so as to aim at the object with both balls. The idea is original, if not practically effective, as it involves a curious problem of the propelling forces. And L. Teutenberg, of Heiter, shows a "rifle with seven barrels," which he designs for wild fowl shooting, as all the barrels can be fired and loaded at once; here again we are met with a similar difficulty, assuming the rifle to be fit for ordinary use, as who can calculate the mutual action of the barrels on each other, all being subjected at the same moment to the violence of a discharge. Messrs. Sellier and Bellot, of Prague, have furnished a handsome specimen of their manufacture of percussion caps, and accompanied it with a statistical fact of some importance, were it a little less conjectural and more circumstantial. They state that "the total manufacture of 'caps' for sporting guns in Europe may be estimated at one thousand three hundred millions yearly, and that some idea may be formed of its importance from the quantity of copper requisite for its production, viz., 396,000lbs. weight." Their "caps are distinguished by accuracy of bore, malleability of the copper,

superior quality of powder, exact adjustment of the proportions so as to insure ignition without danger of accident, and by lowness of price when the quality is considered. Their varnished caps may remain in the water for seventy-two hours without losing their power of immediately igniting." This is quoted simply to show the variety of forms which puffing assumes: here we have it as fresh and as fair as Messrs. Moses are in the habit of issuing their invitations to the public, and none but those who have read the glowing descriptions of the Whitechapel garments, and compared them with the garments themselves, can have an idea of the immense distance there is between the imaginative quality of the brain, and the manipulated quality of the shop—"Hyperion to a satyr," the Whitechapel poet's fancy to the sham and shabby-genteel article of his employer. And so it is with these "caps," when compared with either Walker's or Joyce's, especially the former, where your practical eye can detect at once their quality, their substance, and, what experience has over and over again proved, their safety. We question much if the Austrians equal the French in the manufacture of caps, and every gunsman knows the quality of the latter. The Maison Givelot, of Paris, have also a case of caps, excellently arranged for show; beyond that observation we will not venture.

Before we close these remarks upon the foreign contributions, we cannot refrain from noticing the beauty of finish, the variety, and the exquisite ornamentation of the fire-arms of France. In all these respects they present a model for imitation; as regards the quality of the instrument there can be little question, judging by what we have already accomplished, and by the specimens of our own manufacture in the Exhibition. A gun, as we have already remarked, must be tried before it can be pronounced a good and safe article, unlike, in that respect, almost every thing else; for our sight or touch, or both combined, are generally right in guiding us to a just conclusion when judging of most other articles. Not so as regards a gun.

## CHAPTER IV.—COPPER, BRASS, MIXED METALS.

Copper is one of the metals which is almost invaluable, from its fitness and adaptability to such a variety of manufacturing purposes. It forms the basis of almost all our ornamental metals, and when

used alone there is no metal, except iron, that contributes more largely to the convenience of man.

The process the "cake" or "tile" of copper undergoes to prepare it for subsequent application is that of being rolled. The power of machinery required for this process, irrespective of its ingenious construction, at once commands the admiration and attests the marvellous grasp which the genius of man has acquired over the inert mass of materials, which he turns to his purpose and fashions to his wants. Let the reader imagine a cake of prepared copper, about one foot and a half long, one foot wide, and weighing about 100 pounds, placed in an oven, and heated to the required state; and then let his imagination follow this cake through the following stages, and he will have a faint conception of the power and skill called into requisition for rolling the metal. When sufficiently heated, the metal is drawn from the oven and placed between two enormous rollers, revolving by means of a sixty or one hundred horse-power engine, which flattens and lengthens it to a certain size. It is again heated and rolled until it becomes reduced to a quarter of an inch in thickness, when it is placed under enormous shears, which cut it like a ribbon to the required form. After rolling and cutting, the metal is placed in a trough and well pickled, to remove all impurities from its surface. The metal can be rolled to any given thinness, according to the construction of the rollers. These rollers are also deserving of notice. They are solid cast-iron, carefully prepared to obviate breaking, have a highly-polished surface, and measure about four feet long, by seventeen to twenty inches in thickness. They present a surface like a mirror, and are worth from £30 to £50 each, the polishing process being effected by emery and oil. The copper described is generally used by braziers. The sheathing process is precisely the same. The rolling of brass is similar, except that cold water is used to prevent the heat, generated by the enormous friction of the process, from destroying the equality of the surface of the rollers. The brass is annealed after being rolled, and can be reduced to any given tenuity. Gold, silver, and steel are treated in the same way, cold water being used to obviate the friction, and prevent the uneven expansion of the rollers. The prepared steel is first cut into strips or ribbons, transversely to the grain of the sheet; then they are annealed in an oven, after which they are "pickled" in a strong acid to cleanse them, and the ultimate process is rolling, when they are reduced to the thinness required. We minutely examined these several processes at the rolling-mills of Mr. Charles Clifford, Fazeley Street,

Birmingham; whose courtesy and intelligence we thus publicly acknowledge, although inefficiently, when compared to the benefit we received.

The manufacture in brass and other mixed metals is carried on extensively at Birmingham, chiefly for ornamental purposes. Brass is not a simple metal like copper or tin, but is compounded of copper and zinc, nearly in the proportion of two of the former to one of the latter. There is a gold-coloured alloy, containing about equal portions of the two mentioned metals. Bronze, for casting purposes, consists of copper and tin, with a little zinc or lead added, the copper forming about eight-tenths of the weight. But each manufacturer has his own plan of mixing the metals, and is constantly trying experiments to vary and improve his required alloys; still the analysis we have given is an approximate basis of all the mixtures. Let us follow this brass through a few of its subsequent applications. Brass tubing is made from sheet metal, by cutting up the sheet into long strips, and bending them round a central coil or mandril, whose thickness equals the intended internal diameter of the pipe. The two opposite edges are made to lap over each other, and in that state are soldered together. When soldered, the tube is cleansed and brightened by means of dilute acid, and is then ready for "drawing." The drawing is effected by a mandril being passed through the tube, which is drawn forcibly through a circle smaller than its external diameter; and being pressed closely on every side, its internal and external surface become regular and smooth. There are other modes of making tubes besides this: in the Exhibition there are specimens of tubes which have no joining, therefore must have been drawn or cast in a mould. The tubes to which we allude are of French manufacture, and deservedly attract attention. When once the rod or tube of brass is made, the turning-lathe, the file, and the drill can transform it into almost any shape that fancy or fashion may devise, differing in this respect but little from the hard metals. Perhaps the casting process is the most important as regards brass and bronze, for these metals are capable of being applied to the whole range of ornamental art, from a simple bracket up to an elaborate balustrade or gate. Witness the gates in front of the Fitzwilliam Museum at Cambridge, by Messenger and Sons, and the nobly-ornamented pair attached to the Marble Arch, which forms so magnificent an entrance to Hyde Park. The casting of these metals is effected in a similar manner to other kinds of castings; that is, by models of clay or wax, and a fine sand which abounds in the immediate neighbourhood of

Birmingham. In some instances a permanent metal pattern is produced exactly like the original model, and from this pattern the articles are afterwards made. Some of the manufacturers have a heavy weight of metal by them in castings alone, amounting to several thousands of pounds in value. The stock of Messenger's casting models is a large capital of itself, and the same remark will apply to Winfield and Sons' collection. There are several methods of giving a high finish to bronze and brass objects, which the metal in its original state would not present. The "verde antique," the warm brown tint, and the metallic hue, are all imparted to bronze by certain compositions applied to the surface after casting. Brass work is brought to a bright yellow appearance by lacquering, which is so skilfully performed that it has the appearance of gilding.

When any of the numerous articles of brass which Birmingham produces has been formed by casting, drawing, stamping, chasing, or other mechanical operations, they are cleansed from grease by being heated, then laid to "pickle" in dilute acid, and brushed well with a hard brush. Each article is then dipped in aquafortis, by which means it speedily acquires a clear bright yellow colour, wholly free from specks and stains; the cleansed and brightened article is then washed in water, dried in hot sawdust, and then burnished. The burnishers are made of blood-stone, and the method pursued is precisely similar in all branches of manufacture; the burnished article finally receives a rich deep tint by being lacquered, or by being brushed over with a mixture of spirits of wine, gum-lac, turmeric, saffron, and one or two other ingredients, which in a compound state is called lacquer. The almost countless articles made of bronze or brass—bells, cannon, lamps, candelabra, ornamental railings, rods, handles, rosettes, scrolls, &c.—are produced by the several processes enumerated, but with certain modifications in each.

With these few preparatory observations upon the processes of manufacturing the metals, and preparing them for ornamental and useful appliances, we shall proceed to an analysis of the contents of the Exhibition, strictly confining ourselves to those branches which are in immediate relation to our preliminary description.

The contribution of Messrs. Winfield is highly characteristic of the busy hive of Birmingham. Their plain and ornamental tubes, which are applied in so many ways for domestic purposes, are probably the best specimens of the kind in the Exhibition. The wire and rolled metals are also entitled to commendation; but the brass bed seems to attract most attention, from its richly-ornamented style

of structure. As far as our taste is concerned, we prefer the brackets and light-pendants, several of which are highly artistic and original, therefore shall leave the multitude of useful articles which present themselves at their stand, for the consideration of those who are more practically conversant in them. Analogous to the preceding contribution is that of Messrs. Peyton and Harlow. The patent beds of this firm appear the most effective articles of the kind that it is possible to conceive, uniting elegance of form and lightness of appearance with facility of use; nor are their ornamental properties less distinguishable. These metal beds are fast superseding those of wood, not only from the healthiness of their use, but also from the ease and facility with which they are capable of being managed, an ordinary domestic attendant, without any external aid, being able to take them to pieces or put them together, so simply, yet soundly, are they constructed. The possessor of these simply-constructed articles may literally take up his bed and walk, whether in the lonely route across the desert, or in the uninhabited pampas of the tourist and the traveller. Let any one, with an eye to comfort and security, examine one of these truly useful constructions, and he will immediately assent to our remarks. The pillars, too, are drawn, and not rolled and soldered in the ordinary way of manufacturing tubes, which imparts to them a greater strength and beauty; in addition to which the separate sections of the pillars are fastened upon a new principle, a strong welding being *cast* round the parts where they join, which makes the latter the strongest instead of being the weakest part of the pillar.

Among the display of brass-work, not the least interesting is the contribution of Messrs. Hardman, the ecclesiastical decorators. This work is distinguished from the casting process, as it is beaten out with the hand, and worked up to the nicest finish by the same means. Those splendid coronæ in the Mediæval room are almost wholly produced by the "cunning" of the hand, the hammer being the principal assistant; and the only wonder is that the manipulative art can be so beautifully carried out, seeing that mechanical and other processes have comparatively neutralised the dexterity of manipulation. This, to our minds, is one of the most interesting branches of metalliferous workmanship, and deserving of attentive examination.

Let us now direct our attention to the splendid group of Messenger and Sons, which, perhaps, is the finest illustration of metalliferous art in the Exhibition, taken as a whole. The group occupies

a prominent but proper position in the western nave, and elicits general admiration. It consists of objects in bronze and ormolu, besides others illustrative of the manufacture, from the first rough casting up to the most finished state of workmanship. The centre of the group is composed of a column and capital in high relief; in the foreground there is a domestic group, in due proportion, of the Queen and the Prince of Wales, one in bronze and the other in ormolu, modelled by Bell, and finished to the nicest touch of artistic excellence. A bronze figure of the "*Iron* Duke" on his charger is placed on the left of the column, and on either side, immediately behind the foremost groups, are specimens of bracket mouldings, elaborate iron scrolls, and groups of animals, interspersed with candelabra, the columns of the latter exhibiting the finest order of workmanship. The bronze balustrade, forming part of the group, is remarkably rich and effective; the quality of the metal and high finish of the work are more than ordinarily remarkable. Directing our view a little way further, we encounter a series of objects of a similar nature, although not so classical and true, either in design or finish, yet withal evincing a fertile if not highly-cultivated taste. The bronze display of Mr. William Potts is highly creditable to the manufacturing excellence of Birmingham. Casting our eye over the multitude of objects, many of which we greatly admired, having seen several in their preparatory stages, our attention was instantly arrested by the boudoir-glass executed for the Duchess of Sutherland. The dimensions of this beautiful metal frame is about six feet long by four wide. The character of the design is somewhat original, representing two naiads seated on aquatic foliage, one on each side of the mirror, but apart from it. The naiads are sculptured in porcelain; and, seated on two brackets, are adjusting their hair, as though they had just been bathing. The reflection of the figures in the mirror is a novel idea. Just above these nymphs are a couple of herons, each supporting in its beak a chain, at the end of which is a pastille-burner; while the toilet bottles rest on a metal scroll, just over a shell, into which the perfumed liquid is supposed to run. There are other ornamental devices round the frame which add to the beauty, while they preserve the character of the original design.

Birmingham is rich in the display of lamps, one of the leading branches of her elegant and refined industry. Salt and Lloyd have furnished a most excellent sample of the skill which we have attained in this manufacture; and J. and H. Ratcliffe have maintained their preceding reputation, if they have not indeed surpassed it. For

originality of design, excellence of work, and beautiful finish, they have few equals in this department of industry.

Glancing for a brief space of time at the useful, we remark the great variety of articles designed for the conveniences of life in metalliferous art. Bell hanging, brass works, door handles, tea bells, cornice poles, and a multifarious collection of devices to consult the comforts of the several sections of society—through the medium, too, of a style and art suitable to the presumed requirements of each. In this useful department Messrs. W. and T. Harcourt seem predominant, and their contribution naturally attracts the spectator who looks with an ulterior view, rather than for the mere object of gratifying a luxuriant and refined taste. In this branch of trade Birmingham may be said to stand alone ; at least the Continent pales its fires before it.

## CHAPTER V.—STEEL PENS.

It may be interesting to many who are daily using this useful article, to know something of the process of its manufacture, and the various stages it passes through in its transformation from a ribbon of steel to a finished pen. We have already described the process of rolling and cutting steel, therefore must crave the reader's attention to the advanced stage when the metal is cut into strips, put into cast-iron boxes, and placed upon a "muffle," where they are annealed or softened by a certain process of heat. These strips are now fit to be rolled into the thickness necessary for the pen. The rollers consist of metal cylinders revolving on each other. A man and boy attend at each ; the first introduces the slip of steel between the opposing surfaces, and the boy on the opposite side pulls it out considerably lengthened. In this state it is ready to be cut into pens by means of a press, in which are fitted the proper tools for cutting out the "blank." The use of the press is to give a regulated amount of pressure to the tools fitted to it. These presses are worked by women, who are so dextrous that the average product of a good hand is 200 gross, or 28,000 per day of ten hours. Two pens are cut out of the width of the steel, the broad part to form the tube, and the points are cut to such a nicety, that there is but little waste. The "blanks" are now taken to be pierced, and here the little central hole and the side slits are cut, by another press. These semi-pens are now placed in a

heating oven to make them softer, after which they are "marked," by the aid of a die worked by the foot, which stamps the name of the maker on the back; the half-finished little instrument is then placed in a groove, and by a machine converted from a flat, into a cylindrical form. This is called "raising" the metal. The pens are again placed in the "muffle," packed in small iron boxes with lids, and heated to a white heat. They are then withdrawn, and suddenly thrown into a large vessel of oil, where they acquire a brittleness that makes them almost crumble at the touch. The next process is "cleaning," then "tempering," which restores the pens to the required elasticity, by placing them in a large tin cylinder, open at one end, and turned over a fire, in the same manner that coffee is roasted. The heat changes the colour of the pens, first grey, then straw colour, next to a brown or bronze, and lastly to a blue. Still there is a roughness to be removed from the surface, which requires the pens to be placed in large tin cans, with a small quantity of sawdust. These cans are horizontally placed in a frame, and made to revolve by steam, the pens rubbing against each other, by which means they are cleaned. After the "scouring" process, they are taken to the "grinding-room," where each individual pen is ground at the back in two ways, at right angles to each other, or rather over each other, the quality of the pen very much depending upon this operation. By the aid of a pair of nippers the girl takes up the pen, holds it for a moment or so on a revolving "bob," and the grinding is over. Now follow the pen to the "slitting-room," where it is placed in a press, where the process is instantly effected. The pens are next examined, and sorted according to their qualities; after which they are varnished with a solution of gum, when they are considered ready for sale.

The name of Gillott is as strikingly identified with the manufacture of steel pens, as that of Joe Manton with guns, or Mordaunt with pencil-cases. If not the inventor, he was the first to establish a manufacture of that useful little instrument upon anything like a scale of magnitude, and, consequently, to bring it into almost general use. Before this ingenious manufacturer applied his industry to the fabrication of a metal pen, the quill was in universal requisition; but now a little bit of steel, after going through a series of transformations, by the "cunning" device of machinery, has become the winged-purveyor of our thoughts, and the ready transmitter of our desires. This, perhaps, may be cited as another striking illustration of the mastery of mind over the material properties of nature, and how the intelligence of man may be exercised in the development of his social and moral

well-being. Turn we now to the contents of the case which refers to the name of Gillott, in the Exhibition. There you may see pens of almost every possible form, from the magnum bonum to the tiniest purveyor of human thought, which requires a microscope to minutely examine its make. The monster pen weighs five pounds, and measures one yard in length; the Lilliputians are about four grains in weight, and are simply illustrative of the ingenious power of our machinery. The monster contains sufficient metal to make 1,092,397 of its diminutive likeness, yet both are cut in all their parts with the nicest precision for use. But perhaps the most remarkable feature in this singular contribution is the colouring imparted to the metal, which is the finest and richest we ever beheld, except some metal-foiling in France, in which our neighbours are particularly happy. The next contribution of importance is that of Hincks and Wells, which is equally remarkable in many respects. These ingenious manufacturers exhibit a gross of pens which only weighs fourteen grains; here, again, we had recourse to our microscopic friend to descry their peculiar excellence, when we discovered that they were mechanically true, and must have been produced by the exercise of the most minute ingenuity. As far as appearance goes, these pens were fully equal to those of Gillott, although not quite so tastefully arranged, which is a purely subordinate point, and scarcely worth noticing. The Messrs. Mitchel have each a contribution of the same article, and, for what we know, may be fully equal in quality to the others; but we must remark, that their mode of arrangement is anything but attractive, and appearance is becoming daily a most important element in our commercial, as well as in our social, relations. The gold pens of Wiley are deserving of attention, from the care apparently bestowed upon their production; in addition to which, if they are only capable of performing a tithe of what is promised of them, they must be considered as a desideratum long sought for, and now found—an everlasting nibbed pen, as the Americans—their inventors, we believe—dubbed them.

## CHAPTER VI.—PIN-MAKING AND WIRE-DRAWING.

Industry developes itself in a variety of forms in the busy hive of Birmingham, and whether in its minute or in its magnitudinous operations, it is equally suggestive of man's power when judiciously

directed. From the rolling of a ponderous lump of metal into a thin sheet, to the making of a pin, or attenuating a thread of wire, there is equally manifest the over-mastering power of the hand when guided by the head—in the dexterity of the one, and the ingeniously-conceived instruments of the other. Man's power, indeed, over the material world has been achieved solely by his mechanical inventions, and his ultimate redemption must mainly depend upon his perfection therein. In every branch of industry this is more or less self-evident; but it is only when his inventive faculty forcibly presents itself either in a machine of a minute or ponderous power, that it strikes upon the imagination with more than ordinary effect.

These reflections were naturally awakened on viewing the process of wire drawing and pin manufacture at Birmingham and the adjacent neighbourhood. The manufacture of pins is not so much localised as many other branches of manufactures in metal. In London, Warrington, and in Gloucestershire, there are large factories; but the newly-improved process, secured by patent, is principally carried on at Birmingham. Before we describe the pin process of manufacture, we shall give a sketch of wire drawing, the preparatory stage of that useful little instrument. Imagine, gentle reader, coil upon coil of what are technically called charcoal and "puddled" rods, fresh from the iron-makers, and varying from a half to the seven-sixteenth of an inch in diameter. The first process consists in pointing the end of each rod; the second in cleansing the rods by placing them in a cast iron barrel, measuring eight feet long, and three feet in diameter, which is driven in cold water by steam-power for ten hours, at the rate of thirty revolutions a minute. This process completely denudes the rods of every objectionable concretion. After this the rod is drawn down on a series of blocks, through hard steel plates, perforated with holes, and graduated to the size of the wire, until the latter attains the required thinness. The fourth process consists in placing from two to three tons of this drawn wire in a cast iron annealing pot, measuring seven feet deep by three in diameter, where it is fined for seven hours; after this the wire is cooled, then cleaned in vitriol. The number of times the wire passes round the blocks, or, in other terms, the velocity with which the block moves, depends entirely upon the thickness of the wire. The thick wires are generally used for fencing and telegraph purposes, while the finer are required for the manufacture of wire blinds, hooks and eyes, needles, brushes, &c., which consume great quantities. Electro, or copper-coloured wire, is drawn through wet acids, and is used for sofa and other springs.

Tinned wire is produced by a swift, or wheel of wire running through boiling tin, after being prepared in acids; it is principally used for lacing and bottling purposes. Wire in a finished state is made up into bundles of 63lbs. each. Number one wire contains 84 yards to the bundle, and number twenty 52 yards. The finer gauges, such as 20 to 36, are made up into 12lb. parcels, number twenty containing 1008 yards, while number 36 measures 18,133 yards. The preceding description of wire-drawing applies to the process carried on at the large establishment of Messrs. Edelston and Williams, of Birmingham, and with a few trifling exceptions, at Messrs. Baron Webster's, Penn, near Birmingham.

The manufacture of pins is carried on under two different forms; the one by hand labour almost exclusively, and the other wholly, or nearly so, by machinery. We shall describe the latter process, as it is fast superseding the former. The first process is drawing the wire to the thickness required for the pin, round a series of blocks already described; the second in straightening the wire, and cutting it into segments from six to eight inches long, which are afterwards pointed at each end on a rotatory file of steel, making about 6000 revolutions per minute. These segments are then cut into what are technically called "shanks," or shafts, of sufficient length for the pin. The third process consists in heading the pin, which is exceedingly ingenious. The head is formed out of the same piece of wire as the shank, by an ingenious machine invented by Messrs. D. F. Taylor, but perfected by their successors, Messrs. Edelston and Williams, which renders it perfectly immovable. By the old method, generally pursued in Gloucestershire and elsewhere, the heads are detached, and frequently slip off the shank; by this process the head forms part of the shank, is solidly constructed, and cannot possibly be separated from the pin. There we observed the manufacture of every kind of pin, from the minutely-shaped one for the entomologist to the blanket pin; and some idea may be formed of the organisation of the establishment when we state that 8000 pins can be made every minute, or about 6,000,000 per day of twelve hours, which, allowing 300 working days for the year, gives the almost incomputable quantity of 1,800,000,000. After the heading process is gone through, the pin is whitened, or silvered in tin, which is a preparation of acids; it is then stuck upon paper suitable for its destined market, bundled and labelled, when it may be said to be complete. Loose pins are put up in half, quarter, two-ounce, and one-ounce papers; sometimes they are placed in boxes of one and two ounces, and sorted in qualities and sizes.

The firm to which we allude in the preceding remarks have sent a singular specimen of their manufacturing excellence, in the shape of a brilliant star of pins, comprising every kind in use, from the three-inch corkin to the minutest entomological transfixer; some in gold, others in silver, and all made in the same way as regards the head, which forms a portion of the metal, and not stuck on according to the ordinary mode of making the article. The quality of the wire, a most important point in the manufacture of pins, as in that of needles, is most carefully attended to by these manufacturers; hence, we presume, the reputation they have acquired in the art. Messrs. Kirby, Beard, & Co., have also a highly creditable specimen of their industrial skill in the Exhibition. Their name is as familiar in relation to pins as that of Gillott is with steel-pens; and, judging by appearances, they seem strenuously desirous to maintain it. Their needles and fish-hooks have not, as yet, acquired the name which those of Redditch enjoy, and almost everything depends on the name in these capriciously little instruments. In pins and needles we have no rivals worthy of the name, amongst our continental neighbours.

## CHAPTER VII.—NEEDLES.

The manufacture of needles is principally carried on at Redditch. No fewer than thirty separate processes are involved in the manufacture of a good needle, affording an example of subdivided employment scarcely paralleled in any other branch of industry. The first process is bringing the steel into a fine wire. Suppose a store-room hung round with hoops of wire, of varied thickness, and each hoop containing on an average about fourteen pounds of wire, the length varying according to the diameter. The sizes of sewing needles vary, but the ordinary sizes range from No. 1, of which twenty-two thicknesses make an inch, to No. 12, of which there are a hundred to an inch. Take No. 6, by way of example. The coil of wire is about two feet in diameter, weighing about thirteen pounds; the length is about a mile and a quarter, and it will produce forty or fifty thousand needles. The size of the needle is gauged by a small piece of steel, with eighteen or twenty slits in the edge, all of different sizes, with a particular number attached to each. The diameter of each coil of

wire is tested by this gauge, and by the number each diameter is known. The coil is next cut into pieces equal to the length of two needles, then straightened by being annealed in a furnace. A number of rings, varying in diameter from three to seven inches, are placed upright on their edges, at a little distance apart; and within these are placed some thousands of wires, which are kept resting on the interior edges of the rings. When red-hot they are taken out and placed on an iron plate, the wires being horizontal and the rings in which they are inserted being vertical. The process of "straightening" or rubbing then commences. The workman inserts a long piece of iron about an inch wide into the rings, and rubs the needles backwards and forwards, causing each needle to turn on its own axis, and also over and under those which surround it. As the wire, when cut from the hoop, is in a curved form, the action of one upon the other makes them all straight; and, by this process of rubbing, any convexity is pressed out. The wires are now about three inches long, blunt at both ends, and dull on the surface; and each of these wires is to make two needles, the two ends forming the points, which are made before the wire is divided. This process is extremely interesting to the spectator, but extremely hurtful to the workman, whose life is materially shortened by pursuing it. The workmen are seated on stools with a bunch of wires in their hands, before a series of small stones, from eight to twenty inches in diameter, rotating vertically about two feet from the ground, and with a velocity amounting to two thousand revolutions per minute; the wires they gently press upon the stones. A handkerchief is wrapped over their mouths to prevent them from inhaling the small particles of steel which float in the air around them, but even with this precaution they inhale a certain portion, which renders the pursuit so destructive to life that few live much beyond thirty years of age. The workman places the fingers and palm of one hand diagonally over those of the other, and grasps the wires between them, the latter being parallel; the thumb of the left hand comes over the back of the fingers of the right, and the knuckles and joints are so arranged that every wire can be made to rotate on its own axis, by a slight movement of the hand, without rolling over the others. By causing the wire to rotate while in contact with the stone, the pointer works equally on all sides of it, and brings the point in the axis of the wire. Every now and then he adjusts the wires to a proper position, against a stone or plate, and dips their ends in a little trough of liquid, placed between him and the stone. Each wire sends out its stream of sparks, which ascend diagonally in a direction oppo-

site to the workman; and so rapid are his movements that he will point seventy or a hundred needles in half a minute, or ten thousand in an hour. It is a curious sight to see many of the workmen pursuing their task in the dark, their faces lit up by the cone of sparks issuing from the grinding steel, which reflects a vivid light upon their pale and attenuated forms, forming a *tableau vivant* worthy of the pencil of a Rembrandt. The next process is to pierce two holes, or eyes, through the centre of the wire, which is to form two needles; this involves great nicety of touch in order to prevent what is called "cutting in the eye." The germ of the eye is given to each half of the wire by a stamping machine and a hammer weighing about thirty pounds: upon the surfaces of the wire the die is impressed in the form of a gutter or channel. In this channel the eye of the needle is pierced. One stamper can stamp four thousand wires in an hour, or eight thousand needles, although he has to adjust each needle to the die. The piercing of the eye is effected by boys, each of whom holds a number of needles or wires, spread out like a fan, which he lays flat on a small iron or slab, holding one end of each wire in his left hand, and bringing the middle of the wire to the middle of the press. Two steel points or cutters are affixed to the upper arm of the press, exactly the size of the eye they are to form, and both these points are made to pass through the wire very nearly together, and at a small distance on each side of the centre of the wire, thereby forming the eyes for two needles. This operation requires a steady hand and good eye-sight, to effect it properly. After the needles are "eyed," a wire is passed through each, which is called "spitting." Two pieces of wire, exactly the size of the needle-eye, are held in the right hand, and a distance apart, corresponding to the space between the eyes in each needle-wire; the pierced needles, held in the left hand, are now threaded upon the wires, and, when completed, the latter have the appearance of a fine-toothed comb. A workman now files down the bur, or inequalities, left on the side of the eye by stamping. The piece of wire, which is to form two needles, is then separated by the dextrous manipulation of the workman, who works the comb in his hands until he has broken it into two halves, each being "spitted" by one of the perforating wires. The "soft-straightener" next takes the needles in hand, which are placed on a small steel plate, by separating them from the group with a bar of a curious form, which is worked with the hand. Each needle is rolled over two or three times with the lower surface of the instrument upon the plate, until every unevenness of surface is effaced; and so quickly is this done that three

thousand needles can be straightened in an hour by one person. The needles are now to be "hardened" and "tempered" by heat, which is effected by placing them in ovens, spread in thick layers on narrow trays of iron, where they remain for a certain time; after receiving the proper degree of heat they are transferred to a perforated vessel, immersed in cold water or oil, where they are cooled and "hardened." If the hardening has been effected in water the needles are simply dried; but, if in oil, they are washed in an alkaline ley to free them from the oil. The needles are "tempered" on an iron plate, heated from beneath, and moved about with trowels until each one has been gradually brought to a certain temperature. They have now to be straightened by small hammers, having become slightly distorted by the heat. This process is performed by women, who, with a light hammer, give a number of gentle blows to the needles, placed in a small steel block with a smooth upper surface, and so tedious is it that an expert workwoman cannot straighten more than five hundred needles in an hour. The "scouring" machine is next called into requisition, which is composed of a square slab working to and fro on a long bench or bed. The object is to make the needles perfectly smooth. A strip of thick canvas is laid out open on a bench, and on this a large heap of needles, amounting to twenty or thirty thousand, is laid, all the needles being parallel to each other and to the length of the cloth. The needles are then coated with a mixture of emery and oil, and tied up tightly in the canvas, the whole forming a compact mass about two feet long and two inches in thickness. Twenty-four rolls being thus prepared, comprising about six hundred thousand needles in all, they are placed under the rubbers of the scouring-machines, two rolls to each machine. The bundles are made to roll over each other, by which an intense degree of friction is excited among the needles, each rubbing the other smooth. This scouring endures eight hours, when the needles are taken out, washed in suds, placed in fresh canvas, touched with a new portion of emery and oil, and subjected to another eight-hours' friction. This process is repeated five or six times over. They are next taken to the "header," who turns all the heads one way and all the points another. The girl sits with her face to the window, and has the needles ranged in a row before her, the needles being parallel with the window. She draws out laterally to the right those having their eyes on the right hand, into a heap; and to the left those which have their eyes in that direction, in another. During the process of "scouring" it sometimes happens that as many as eight or ten thousand out of fifty thousand

are spoiled. "Drilled-eyed needles" are produced by being drilled with a fine instrument, which makes them as smooth in the eye as any other part of the needle. The head is first "blued," or heated, to temper it for working; then the eye is "counter-sunk," which consists in bevelling off the eye by means of a triangular drill, so that there may be no sharp edge between the eye and the shaft of the needle. Drilling succeeds. The workman takes up a few needles between the fingers and thumb of his left hand—spreads them out like a fan with the eyes uppermost—brings them one by one opposite the point of the drill working horizontally with great rapidity before him, governing the handle of the drill with his right hand, and drills the eye, which is equivalent to making it circular, smooth, and polished. By shifting the thumb and finger round, he brings all the needles in succession under the action of the drill, which is prepared with great nicety, being a wire of polished steel three or four inches long, and by which the high finish of the needle is ultimately produced. The heads are now rounded, by the men grinding them upon stones, about five or six inches in diameter, attached to a horizontal axis. These stones revolve about three thousand times in a minute, consequently the needles are but slightly touched by them; after this they are "polished," which may be termed the final process of the manufacture. The polishing wheel consists of wood coated with buff-leather, whose surface is slightly touched with polishing paste; the needles being applied to them in every part successively, first the surface, then the pointed and eyed end, and about a thousand in an hour can be polished by each man. The needle is now finished.

The preceding detail of the manufacture of needles will enable the reader to look with an eye of greater interest, whenever that diminutive and useful instrument attracts his attention,—be it in the glorious Palace of Industrial Art, fresh and glittering from its native workshop, or in the humbler sphere of the domestic circle, where its really useful office begins and ends. Redditch, like its neighbouring hives, has furnished some fine specimens of its industry, which is unequalled throughout the world. The art of needle-making has been perfected there and within a small circle round it; and the manufacturers of Redditch appear to have acquired the art to conceal the art, so exclusively do they maintain their power. Messrs. Bartlett and Sons have furnished specimens of the different stages of the manufacture of needles, already described, which will be viewed with interest by those whose intelligence happens to take that direction; and Messrs. Boulton & Son have imparted an additional interest to their needle

contribution, by accompanying it with steel meshes, surgeons' needles, sail-hooks, bodkins, harpoons, and with other instruments for the sports of the deep. While Mr. H. Hemming, by way of preserving the reputation of the name, has furnished a similar contribution. Extending our view a little farther, we find that Mr. J. James has sent specimens of the different processes of the manufacture of both needles and fish-hooks, which are equally deserving of attention. The general excellence of these contributions necessarily precludes any attempt to individualize their respective merits, and it would require a nice eye, however practical, to discern much difference in them. Like guns, such articles as these are only appreciated after their working qualities are tested, therefore an *à priori* judgment upon their merits would be simply ridiculous, if not something worse. Each maker has his *special* reputation, to which the public tenaciously cling when once clearly and practically established in their minds, and for a very good reason,—that it can only be formed by a series of experiments, many of which involve considerable time and trouble, irrespective of a certain, and frequently a considerable, expense.

## CHAPTER VIII.—BUTTONS.

THE rise, progress, and present excellence of the manufacture of buttons, would form an appropriate introduction to the metalliferous art of Birmingham, as it has long formed one of the staple productions of her busy and prolific hive. The fabrication of the gilt button preceded that of the covered, or Florentine, as it is technically called, and required a considerable amount of ingenuity to keep pace with the adaptation of tastes, which the caprices of fashion are ever and anon in the process of generating; but a greater amount of ingenuity was evoked when the covered button came into general use, as the old method of covering bone moulds by the hand with a needle and thread was superseded by the use of dies and the screw-press. The latter process not only effected a complete change in the manufacture of covered buttons, but it materially enlarged its power, both in the variety and the extent of its production. The first patent taken out for making covered buttons by dies and pressure stands in the name of Mr. B. Sanders, who removed from Birmingham to Broomsgrove in order that he might conceal the process from the prying eye of his

manufacturing contemporaries; but as he soldered iron shanks to the back of his covered buttons, it was some time before the public became reconciled to them, from the general dislike to that form of shank. On the expiration of his patent in 1828, Mr. Sanders cut away the iron shank, and substituted the present flexible or woven shank, for which he attempted to establish a patent; but the objections against it were so strong that it was refused, as the flexible shank, made of catgut, had been in use fifty years preceding, the manufacturers of the gilt buttons having applied it. The rejection of this patent had the effect of opening the trade to the town of Birmingham, which has since become so important, not only from the number of hands it employs, but also from the almost constant demand which it creates for ingeniously constructed machinery.

The material of which buttons are made is somewhat various, which gives rise to a subdivision of labour resembling other branches of manufacture. There is the well known gilt button, plain and figured; there are plated, silk, Florentine, and other covered buttons; pearl, horn, shell, bone, wood, glass, and porcelain buttons. Most of these are made at Birmingham. We shall briefly describe the process of making a gilt button. The metal is a compound of copper, &c., rolled out to certain dimensions, and cut into "blanks" by the screw-press. Females generally, almost universally, perform this operation. Take, for instance, what is called a "shell" button, which is hollow, and made of two pieces of metal, one for the front and the other for the back. The button requires two blanks, one called the shell and the other the bottom. The shell is pressed to a convex shape by a machine similar in principle to the punching-press, but having a curved polished surface to act upon the metal, instead of a punch. The blanks, as they come from the punching-press, have a rawness of edge which requires to be smoothed to fit them for their after appearance. This is done by turning them in a lathe: in order to bring the two parts of a "shell" button together, they are subjected to the action of a die and punch, so peculiarly adjusted that the edge of the shell becomes bent over and lapped down upon the bottom, securing the two together in a way at once firm and neat, without the employment of any agent whatever. The surface of the button has sometimes a device upon it, which is produced by means of a die worked by the foot. The man places a button on the lower die, raises a heavy weight, to the lower part of which the upper die is attached, and allows it to fall with great force, by which the button becomes indented with the figure of the die. The "shanking" is rather a

singular process. The shank is not made upon the premises, being a distinct occupation; the machinery to twist that simple bit of wire is very expensive, therefore must be worked on a great scale to become profitable; so that one shank-twister supplies several button-makers. The shanks are made of brass wire, and vary from eight to forty gross per pound weight. The blank, or body of the button, being ready to receive the shank, a woman takes up the latter and places it in the proper position on the button; at the same time she takes up a little piece of bent iron, capable of acting as a spring-clasp, which holds the shank tightly to the button; she then puts a piece of solder at the foot of the shank, which, when finished, is placed on an iron plate, and exposed to a heat in the furnace sufficient to melt the solder and unite the shank firmly to the button. This process is performed with great celerity. The mode of silvering is as follows. The buttons, after being thoroughly cleansed in an acid solution, are put into an earthen pan containing a dry mixture of silver, common salt, cream of tartar, and other trifling ingredients. The buttons are well worked up with this mixture, and in the course of a minute or two the whole are coated with a clear and equable surface of silver. The gilding is rather complicated. It is necessary, also, to observe the distinction between "yellow" and "orange" gilding, the former being affected in colour by the previous use of a mixture called "similor," made of zinc and mercury. Take an "orange all-over," for example. When properly cleaned, they are placed in an earthen pan with "quick-water" and gold-amalgam, which chemically act upon each other. The gold is mixed up into a kind of paste with mercury, which, however, will not act upon the button unless a thin film of mercury be previously deposited on the surface, and the "quick-water," or gilder's aquafortis, a solution of nitrate of mercury, is used for that purpose. When mixed together in a pan, a chemical action is produced between the copper of the button and the mercury of the quick-water, and the required result ensues. The next object is to get rid of the mercury, which is effected by placing the buttons in an oven, and subjecting them to a strong heat, which causes the mercury to evaporate; a careful arrangement of flues being adopted to carry the latter to condensing chambers, where it resumes its metallic form. Then succeeds the "burnishing" process, which is effected by placing each button upon a lathe, when the workman applies to it a bloodstone, which produces a brilliant surface in a few seconds. We are indebted, in a great measure, to the Messrs. Elliott & Son for the preceding details, having minutely examined their large and well-

arranged establishment at Birmingham, where we received every courtesy and attention.

In the same establishment we also observed the process of manufacturing Florentine buttons. Two circular bits of iron, a bit of pasteboard, a bit of thick canvas, and a bit of lasting or silk, are cut out by stamping each circular disk, and the mode of fixing these "bits" together is somewhat curious. There is no glue, riveting, screwing, plaiting, or other mode of fastening; all being fixed and adjusted by stamping or pressure. Within the outer cloth covering is an iron casing called the "shell;" within this is a disk of paper, then one of cloth, and at the back of all a disk of iron, having a hole in the centre, through which some of the canvas is forced, as a means for sewing the button on the garment. All these are placed, in their proper order, in a die, and a descending punch, worked by a press, first fixes the cover to the shell, and then these two to the other three bits, curling up the edges of the two disks of iron in such a way as to enable them to clasp all the five bits firmly, and to hide all imperfections on the edge. The internal mechanism of the presses—some of them being invented by Mr. Elliott himself—is exceedingly ingenious and effective. There are a great variety of covered buttons; but the main features in the manufacture are the punching out of separate little disks, and the fixing of these by pressure. We believe we are indebted to the same firm for the white linen button, one of the recent novelties of industrial art. They consist of a tin or white metal ring, over which a disk of linen is stretched, and the mode of fixing them together by the press is singular and ingenious. All these operations are performed with incredible rapidity by females; and although to put together a single button fourteen pair of hands and a number of machines are employed, a set of fourteen buttons can be sold for 1d. or 1½d.

One of the most recently invented methods of making covered buttons has been patented by Messrs. Chatwin & Sons, of Birmingham. The ingenuity is not the only recommendation of this new mode; it is also more economical in the use of material than the one it is fast superseding. The covering for the front of the button is kept down by turning over the circumference of the shell upon which it is placed, then the latter is forced through a machine which fixes the covering upon its surface, instead of placing the covering between the back and front parts, according to the ordinary method. There is a saving of about one half the silk in this invention. These manufacturers have also introduced another improvement which is equally deserving of

notice. A braiding, or edged border, is made round the button, which not only adds to its appearance, but protects the surface from so readily wearing out. A great improvement has also been effected in the designs for woven fabrics used in the manufacture of buttons. Ten or twelve years ago, the woven figure of a flower for the centre of a button would have comprised merely the outline of two or three leaves, and a small dot in the centre; but the weavers of Spitalfields have been stimulated to such an extent, that in the woven designs for small buttons even the minutest point, or mark of the pencil, is now preserved, whether it be in satin or terry velvet. In this branch of manufactures ingenuity keeps pace with the growing wants of the age, as may be observed in the covering of nails for the general ornamentation of furniture, the old brass-headed nail being now but little used. These covered buttons are a great improvement as they correspond with the material to which they are affixed, and prove that a more refined and subdued taste is gradually introducing itself.

The manufacture of the pearl-button is simple, yet interesting; the button is placed in a lathe, and after passing through four or five operations, is considered finished. The material of which it is made is brought from the Eastern Archipelago, principally from the coast of China; it resembles a large oyster-shell, in almost every respect, and is found in considerable quantities in the eastern seas, being formerly brought home as ballast. But since the shell has been applied to the manufacture of buttons, a ton of them is worth about £19. The waste is considerable in the processes of the manufacture of this kind of button. The horn-button is a distinct branch of manufacture. The hoofs of oxen, principally derived from South America, are boiled and cut into certain forms, which are punched with a screw-press into little circular pieces. These pieces are then dyed with logwood, which gives them a blue-black appearance, after which they are subjected to a heavy pressure with a die, which stamps upon their surface a pattern. The dies in all the button manufacturing establishments form a large item in the plant, their weight of metal, irrespective of the expense of cutting them, amounting in some instances to several tons.

In the multitude of small articles which may be denominated Birmingham *specialities*, to Anglicise a French phrase, we have a considerable display, in one department or other, in the Exhibition. Not only in the manufacture of the metal button, but in steel ornaments, in brooches, bracelets, studs, book-ornaments, glove and parasol fastenings—in short, in almost every conceivable article for ornamental and useful purposes which the inventive genius of fashion

or convenience can possibly suggest—the variety is singular and abundant. In the well-arranged case of Charles Rowley, for example, whose manufacturing genius seems to take a minute direction, these multifarious articles may be found, and they are well worthy of examination; for their manufacture involves a considerable amount of capital, a minute division of labour, and the employment of a great number of hands. The die of that metal button, with its high relief, must have been cut to the nicest precision; nor was the dexterity of hand to impress it on the button, and finish the latter throughout, one jot less remarkable. Look at that weaver's mail, or the small eyelet-hole button for gloves, braces, &c., then you may trace a similar minuteness of work, both in hand and in machinery. Ten years ago that eyelet for stays was selling at 3s. per gross; now it can be obtained for 3d., as good, aye better, in quality, and yielding quite as much wages to the labourer. That wire-loop button is equally ingenious, and equally useful, being so shaped that it obviates the cutting of the thread. Then—but we are tired of enumerating these ingenious yet highly useful contributions.

Before we close our article on metalliferous works, let us glance at an unassuming, yet interesting branch—Hollow Ware, as it is technically termed. The principal seat of this manufacture, which, we believe, is worked under a patent, is at Wolverhampton. Now, reader, just as you emerge from one of the lateral avenues into the western grand nave, exactly opposite Chubb's locks, to which we have already called attention, you will find a few saucepans, in company with other humble vessels and implements, and looking for all the world as though they had no business to be amongst such fine company. Nevertheless, take one up and examine it; you perceive that they are whited with enamel within, and varnished black without, but the former is the principal feature, as it enables every one who possesses them to cook their food in a clean manner, and to have no apprehension of deleterious consequences. Just, if you please, transport yourself from that bright and brilliant structure to a dun casting smithy at Wolverhampton, as though you were quitting the enchanted palace of some fairy to take up your abode in a gasometer, and then you may observe the process of manufacturing that useful little vessel yclept a saucepan. First, the casting process. You are now in a long gloomy building, full of men and boys in a swarthy condition, and stripped to the shirt; most of those fellows are working as hard as their limbs will allow them, the boys shovelling up a dark fine sand which has just been emptied from the mould, and the men kneading

the sand into the moulds at their respective troughs, so as to form the matrix of whatever they may require the molten metal to run into. In the mean time the furnaces are melting the iron, which will be shortly tapped and poured into the matrices, where it soon solidifies. The saucepan, after passing through a variety of stages, which we have not space to detail, is now ready for the enamelling process. A mixture of a perfectly homogeneous nature is prepared, spread equally over the inside of the saucepan, and fixed by means of a fine dry powder. The saucepan is now placed in an oven, well heated till the concrete fuses, when the enamelling is complete. There is required great dexterity of hand in almost all the processes of the manufacture of this article, as it is fashioned to every shape that may be required in any part of the globe. The Messrs. T. and C. Clark and Co. are the manufacturers whose establishment we examined, and observed the processes here somewhat too briefly enumerated. The manufacture of hinges at the same place is equally deserving of notice, as they are exported to almost all parts of the world, having a peculiar shape and make.

One word to the Birmingham workmen. In our humble opinion they are, taken as a class, the best mechanics of the day. This fact became thoroughly impressed upon our minds after minutely observing the different branches of manufacturing industry in that town, the superiority of manual skill over that of mere mechanical labour being visible in almost every direction. At all our great manufacturing seats, with rare exceptions, the human being is subordinate to the mechanical power, or, in other terms, he works up to the machine; but in Birmingham the machine may be said to work down to the man. In most of the leading manufactories here, the dexterity of the hand is predominant in the fabrication of the articles, and, in some instances, to such a nicety is that dexterity displayed, that it surpasses the finest productions of mechanical power.

In fashioning the vessels for electro-plating, and the brass-ornamental works for ecclesiastical purposes, it is especially so; and what gives a zest to the distinction between the manual and mechanical power of the workmen, is the fact, that the majority of the class to whom we especially allude, are a sober, industrious, and well-ordered body of men; studious to improve their condition, and sensitively alive to the mental movements of the day. Having mixed much with them, understanding their feelings, and fully appreciating their peculiar excellence, we should be wanting in ordinary discernment, and indifferent to human progress, did we not thus publicly acknowledge these phenomena, in relation to the interesting community of Birmingham.

## CHAP. IX.—PLATE, SHEFFIELD PLATE, ELECTRO-PLATE.

The general application of the precious metals to manufacturing purposes, although of recent date, presents a wide field for practical observation, and deserves to be ranked with the choicest branches of industrial art. We are indebted to science for this new and beautiful discovery. The consumption of gold and silver was comparatively limited until chemistry revealed the secret properties of their nature, and by her searching analysis pointed out to industry the varied uses to which they might be applied.

The manufacture of articles for general purposes, on which a surface of silver or gold is applied, to a groundwork of inferior metal, has, consequently, materially enlarged the consumption of the precious metals; and it is no uncommon thing now-a-days to observe objects of silvered art on the sideboards of the middle classes of society, which have all the external beauty of their more rare and costly prototypes, and are in nowise inferior to them either for ornamental or for useful purposes. The skilful aim of industrial art, we apprehend, is to produce the *utmost possible effect with the smallest possible means*, and the electro-plating of metals, upon the newest process, is daily furnishing proofs of the truth of that economical axiom. Your vessels of gold, and your vessels of silver, in every age of the world, have been equally sought after by the great ones of the earth, and the value of either one or the other has occasionally been more highly esteemed than the produce of a whole province, or even of a petty kingdom. Homer relates that the ships of Tyre were in the habit of visiting the isles of Greece, in order to seduce, or kidnap, the young Greeks, whom they sold in the Asiatic market as slaves. The Phenician pirates effected their purpose by exhibiting a gold chain, or some other costly and glittering toy, before the wondering eyes of the simple and unwary Greeks, and the estimation in which such articles were then held may be divined by the words which the poet puts in the mouth of Eumæus:—

> "Freighted, it seems, with toys of every sort,
> A ship of Sidon anchor'd in our port.
> * * * * * *
> An artist to my father's palace came,
> With gold and amber chains, elaborate frame;
> Each female eye the glittering links employ;
> They turn, review, and cheapen every toy."

The adventurous and enterprizing Phenicians sent their ships to the Baltic for the amber, an arduous voyage in those days, and received the gold from the distant kingdoms of Arabia in exchange for

their merchandise, so that the value of the raw material may easily be divined; then there was the labour employed upon that raw material, which must have been expensive, notwithstanding the reputed skill and cunning of the Tyrian workmen. Under these circumstances it is clear, then, that the few alone could indulge in such rare and costly articles; and as we come down the stream of time, and observe the bubbles of empires, kingdoms, and states that here and there have floated their hour upon its surface, we shall find among their more glittering portions, if we may be allowed the metaphor, but little diminution in the value of articles of gold, and of the precious metals, almost even to the present day. From the time when Solomon contracted with Hiram, whose father was a worker of brass and other metals down at Tyre, the great workshop of the world—the Birmingham of that day—to construct his palace, even down to the period when the great captain of the present age received his service of gold plate from Portugal, the precious metals, either as articles of use or ornament, and especially in gold, have been dearly prized, and most eagerly coveted, even by the refined and fastidious few. The labours of Hiram, the "cunning" worker in precious metals, must have cost Solomon a good round sum, as much, indeed, as the produce of a large slice of his then kingdom; and it is fair to presume that the gold service of the Iron Duke was, in value, equal to the average annual produce of the whole province of Oporto. By a simple discovery, then, we are enabled to obviate the difficulty which has hitherto accompanied the use of objects made of such expensive materials. Whole provinces need not now be beggared for a period, in order to gratify the refined, though somewhat useful, taste of the luxuriant few, as the recently improved process of electro-plating can supply the means upon more economical terms. The cost of an object of art, manufactured by the electro-typing process, is about one-fourth of those which are composed entirely of silver; yet they have all the beauty, the refined taste, and the pleasing and instructive aspect, as though their every atom were a portion of that precious metal. There is, on the best manufactured articles, a thick coating of silver, which, with fair usage, will almost last the lifetime of an ordinary aged individual; and in every sense they are fully equal to their more costly rivals, if we except the impression, which may occasionally arise in the mind of their purchaser, that they are not composed of a pure and homogeneous metal. A mind, however, that is influenced by such impressions as these, is too apt to lose sight of the end by paying too much homage to the means by which it must be attained, for where can be the difference between a Benvenuto Cellini cup,

for example, manufactured upon the improved electro-typing process, and one composed of genuine silver, assuming that the same art has been employed upon both. Why is that form of cup so highly prized? Simply, we apprehend, from the beauty and the refined spirit of art which it exhibits; and are not these qualities as prominent in a cup thickly coated with silver, as in one entirely composed of that metal? Unquestionably. And these remarks are equally applicable to other objects of use and ornamentation, which are now becoming more widely diffused, and mainly so through the instrumentality of the process of electro-typing.

The art of electro-plating, or electro-typing, as we have already remarked, is but of comparatively recent date. The principle involved in the art may be mainly stated as follows:—Water consists of oxygen and hydrogen, and if a metal (zinc for example) which has great affinity for oxygen, is immersed in water, there is a tendency to decomposition, the oxygen combining with the zinc, which forms oxide of zinc, and the hydrogen being liberated. But in order that this may take place, it is necessary to put in the same liquid a piece of copper, which has less affinity for oxygen than zinc has, and to connect these two metals by a piece of wire. A decomposition of the water and the oxidation of the zinc ensues, and while this is going on, there is a current of electricity passing invisibly through the whole arrangement in a continuous circuit. This may be called the basis of the art; the superstructure is the result of practical observation. It was observed that when the electrical current passed through a solution of sulphate of copper, in a particular form of battery, the sulphate became decomposed, separated the copper from the sulphuric acid with which it was combined, and deposited it in a fine metallic state upon the inner surface of the vessel which contained the liquid. On removing carefully the thin coating of copper from the vessel it presented an exact counterpart of its surface, even to the minutest line and spot. From this simple incident may be traced the different processes of electro-plating, &c., as it established a great fact —that if a galvanic current passes through a liquid containing sulphate of copper, the latter will become precipitated on any surface fitted for its reception, and will present an exact counterpart of that surface. It was soon discovered that not only copper, but silver and gold, as well as the lower metals, could be precipitated in a metallic form from their solutions; and not only can a superficial film of these metals be deposited, but a solid substance of pure gold, silver, or copper, can be composed by such means.

The mode of *plating* is entirely distinct. The French mode of silvering, by laying leaves of silver on heated metal, was so defective, that it led to the method of plating, which is purely an English invention. An ingot of copper and brass is first made about twenty inches long, three broad, and one and a half thick. The surface of the ingot is cleaned, and a sheet of silver, about one-fortieth the thickness of the ingot, is laid on it. The two metals are then tied together with wire, touched at the edges with a little borax to act as a flux, and exposed to the heat of a furnace, which solders them firmly together. The ingot is then rolled into thin sheets, which are stamped, punched,or hammered into the shapes required, the copper forming the basis and the silver the surface of the article. The "solid silver edges," as the process is called, is a great improvement upon the old method. A sheet of silver is rolled very thin, then stamped into forms by dies, swages, and other apparatus, the hollow cavity thus formed being filled up with a solder of lead and tin. These "edges" are then soldered on any article of plated ware, and are stronger than the old hollow edges, besides appearing more sightly when the silver is partially worn off, as they present a whitish ground instead of one of copper. The real gold and silver plate is manufactured by mechanical means similar to those used in the plated manufacture. The articles are either cast in molten metal, or hammered and stamped from sheets, and brought to a highly finished state by chasing, engraving, and burnishing.

These are the ordinary processes of manufacturing plate, plated-wares, and electro-plated articles. We shall now confine ourselves to articles coated by electro-chemical agency. The body before plating is a whitish metal, of greater strength and hardness than silver itself, and is a compound of nickel, copper, and zinc. When in a molten state, the metal is, in some cases, poured into sand moulds, which are impressed by means of prepared models, and when cooled it comes out a perfect countertype of the latter. Sometimes an object is cast whole, if it be comparatively simple in its form; but it is uniformly cast in separate parts whenever a complication of figure is involved in its construction. These parts are then soldered together in the ordinary way. The process of stamping comes next, and is performed as follows :—The metal, being rolled to the required thinness, is placed upon the surface of a die, when a heavy hammer, of the reverse form of the die, is made to fall upon the metal, which receives the precise form of the impression. The dies are of steel, while the face of the hammer is usually of copper, and the weight and cost of metal for this process, in a first-class establishment, are a somewhat

heavy item. The stamped metal is now taken to the polishing department, where it receives a surface, through the agency of emery, sand, or rotten stone, applied by hand and brush, when it is suitable for the reception of the electro deposit. But, before we describe the latter process, let us glance at the brazing operation, which, perhaps, is the most surprising of all, at least as far as manual dexterity is concerned. Many articles are also brought into form from the sheet by the aid of the hammer. The hammer generally used by the workmen is made of hard wood, such as box, and covered with buff leather. There are also *bosses*, or supports made of wood, on which the plate of metal rests while being hammered. With these simple instruments the process is conducted, the subsequent form depending upon the nicety of touch of the workman, which, in many instances, is truly remarkable. The next stage in the manufacture is "mounting," which simply consists in joining the various parts together by means of hard solder, such as the handles, the borders, or any ornamental part, most of which have been under the hand of the graver. We now arrive at the silvering process. The solution of silver employed by the firm, whose mode of manufacture we are now describing—the Messrs. Elkington and Mason, of Birmingham, and who have placed this beautiful branch of industrial art in its present elevated position, is formed by dissolving an oxide, or salt of silver, in cyanide of potassium. The length of time required for this operation depends upon the coating of silver to be transferred to the article, and also upon the proportional amount of silver in the solution. The arrangement is the same in all electro-plating processes. The articles to be coated are attached to a wire in connection with a zinc plate, which may be termed the positive pole, and immersed in a solution of silver ; a plate of silver, in connection with a plate of copper, the negative pole, is placed in the same solution, when it becomes dissolved, and is transferred to the articles by a current of electricity passing between them.

The "gilding" process is effected in a similar manner. Solutions of gold are formed in the same manner as solutions of silver, but as a less deposit of gold is generally required, the operation is completed in a much shorter period; the silver requiring from five to ten hours duration for a thick plating, while gilding rarely requires as many minutes or seconds, the coating generally being much thinner. There is also another method of gilding which is deserving of notice, as it is generally adopted in France. It is gilding by "immersion" only. This process was discovered by Messrs. Elkington in 1836, became the subject of a patent, and received the award of the gold medal from

the *Société d'Encouragement*, and the prize of 6000 francs from the *Académie des Sciences*. The gold in this process is held in solution by the bicarbonate of potash, which, at a boiling heat, dissolves a portion of the copper to be gilded, when an equivalent of gold is deposited in its place, the surface of the latter protecting the copper from further action of the potash. The next, and final process, is that of polishing or burnishing, which depends upon the character of the articles; the former being generally applied by means of rubbing the surface with a burnisher dipped in soap and water. The burnishing instrument is either formed of a bloodstone, or polished steel, and many of them vary in shape. The process of polishing is generally applied to forks, spoons, and other articles of a similar shape, and the friction and pressure which they are subjected to proves clearly that they must have received a pretty thick coating, or deposit of silver. The burnishing process is equally trying, and requires an equally resisting body, in the shape of a thick deposit.

We have hitherto confined our observations to simply covering inferior metals with a superior coating, which was considered, and justly so, as a great triumph of industrial art; we have now to detail a still greater triumph which electro-chemistry has achieved, and which has placed it among the wonders of even this creative age. By electro-deposition the actual substance of the article can be wholly formed from a liquid solution, and the process of formation may be described as follows:—First, the intended article is modelled in wax, then the model is moulded in lead, from which a brass pattern is cast, which is brought to the required degree of finish. From this pattern a second mould is made, composed of a yielding and plastic material; and from the latter a composition model is cast, which forms a surface on which electro-deposition is to take place. The composition model is next transferred to a vessel where a deposit of copper is induced by galvanic agency, the substance of the deposit depending upon the circumstances under which the operation is conducted. The composition model is now coated with a layer of copper, and the next step is to melt the former, and leave the copper shell, the interior of which exactly corresponds to the exterior of the model. After a further preparation the copper mould is immersed in the gold or silver solution, the interior being prepared for the reception of the deposit, and the exterior prepared with a resisting composition. The precious metal is now deposited in the copper mould to any required thickness, after which the copper is subjected to the action of a strong acid, which gradually eats it away without injuring the silver, and the result is

the production of a pure and genuine article of silver or gold. The article when fresh from the solution has a dead appearance, the silver in particular, and to give it a brighter surface, it has to undergo the process of burnishing, which we have just described. Large surfaces of electro-typed articles are subjected to what is called "planishing," or hammering. This imparts an elastic, uniform texture to the article, by bringing the metallic particles into more intimate union with each other. The hammer is made of highly polished steel, and requires to be used with considerable dexterity of hand, in order to effect the desired purpose.

There is one peculiar advantage connected with electro-typing which is especially deserving of notice; it is the only means yet discovered of multiplying the beauty and excellence of the originals in art. In painting we are limited to the engraving, with its cold black and white, to multiply the original, the transcendant media of colours, for the highest efforts of genius, being substituted by their comparatively uncongenial and repulsive negatives. The electro-typing process, on the contrary, is capable of multiplying the objects of art to an almost indefinite extent, and with all the beauty, the spirit, and the fine intellectual touch, as though they were fresh from the brain of their creator. Take, for example, the Warwick Vase, electro-typed by the manufacturers just mentioned: in that object you have the exquisite touch and skill of its antique originator, as fresh as when first conceived and executed by his hand. Again, look at the reduced copy of the Theseus, wherein you have an exact counterpart of the original, both in the decayed portions, and in those which still preserve the fine lessons for anatomical sculpture. By no other process could this be obtained; and the advantage derived from it, even in this isolated instance, is considerable, as students can now procure copies of the best specimens of the antique in the British Museum to study from, who have neither the opportunity nor the means to visit that building.

Let us now step out of the "workshop" and range our eye over the objects in the Exhibition which have an immediate bearing upon the preceding remarks. First in importance must be classed the productions of Messrs. Hunt and Roskill, better known as Storr and Mortimers, not so much for the beauty and originality of their works as for the richness and variety which they display. They have literally transferred their shop to the stalls of the Exhibition—at least, there is an epitome of it. Jewels, diamonds, and precious stones of rare beauty are glittering in all directions the moment your eye meets their large contribution; and this, we apprehend, is the chief cause of attrac-

tion, and not the artistic merit of their productions, several of which are of a mediocre quality, when compared to those of one or two of their neighbours. The finest work which Hunt and Roskill exhibit, to our conception of artistic beauty, is the large candelabrum, standing in the western nave, and quite apart from their large show-box up stairs. There they seem to have attained the true aim of art—the utmost effect with the most limited means; there is a richness of character, yet withal no heaviness, the great fault of almost all our productions, and the effect is at once striking and impressive. The burnished branches form a beautiful contrast to the dead shaft, and the base is most elaborately light, yet well supportive of the superstructure. The design, also, is highly effective. Most of the leading and large objects up stairs are well known to the public, and have been borrowed from their respective owners, we apprehend, simply to make a "show," not exactly contemplated by the purport and spirit of the Exhibition. The same remark will apply to Messrs. Garrard's display, which is likewise composed of contributions similar to the preceding, their chief and almost exclusive merit being an *embarras des richesses.* There appears such a ponderous waste of the precious metals in the majority of these productions, as though John Bull could not tolerate anything, even in the fine arts, without its assuming a solid and substantial appearance. Pieces of this solid order of plate, it is true, are of rare occurrence; but seeing so many collected together, and all of the same pursy, puffed-out kind, we cannot but wish that they were all melted down, and the proceeds applied to the production of really artistic works. We never saw so small an amount of really good art expended upon such splendid materials; or, in other terms, we never saw such rich materials perverted by so much comparatively useless labour and inferior art. We shall, however, select two objects which display a more than ordinary amount of talent, and are not justly chargeable with the demerits we have endeavoured to point out. The candelabrum of Messrs. Garrard is an original and poetical conception of a fine subject—the "Halting of Saladin and Sir Kenneth" at the fountain beneath a knot of palm-trees, so pictorially described by Scott in the "Talisman." The easy, oriental attitude which Saladin assumes, as lithe as his fine-tempered Damascus blade, and the stalwart, cool, and unblenching expression of the knight, are admirably preserved. The artist has evidently caught the spirit of that highly dramatic incident; you see it in the expression and attitude of the two principal figures; you also see it in the subordinate, yet really effective, addenda of the trees and other

surrounding objects. It is, to our taste, an exquisite piece of art, and not overloaded with material. The other object may be seen in the collection of Messrs. Hunt and Roskill. There is a testimonial to Sir Moses Montefiore, commemorative of his Eastern pilgrimage, under the form of an allegory. It was designed by Sir G. Hayter, and modelled from the design, evidently, too, with a good spirit and an artistic feeling. The treatment of the subject is not strictly according to the chronological order of events, nevertheless the artist has managed to embody one or two of the grandest pages in Jewish history. The captivity of the Israelites is typified by the Egyptian sphynxes; their deliverers are represented in the figures of Moses and Ezra, and the delivered in a Jew of Damascus in chains, and another set free. The apex is represented by David rescuing the lamb from the lion, and the reliefs illustrate the passage of the Red Sea, and the destruction of Pharaoh and his army. Sir Moses and his lady are figured as landing on the shores of Egypt, and receiving the diploma of their peaceful mission. The grouping, the character of the figures, the just and subordinate keeping of all the parts, and the general treatment of the subject, stamp it as a work of great and rare merit.

We shall now pass to the case of Messrs. Morell, where may be seen a horse standing upon two legs, and, what makes it more uncommon, is the circumstsnce of the animal not having one "off" and one "near" leg up at the same time, but he actually has both the "off" legs up and the "near" ones down. You really tremble to see the poor thing standing "upon such dangerous ground," and naturally expect that he will topple over and break through his glass covering, rider and all. To be sure he is a silver horse, and no doubt well fixed upon his pins, otherwise—we all know what must ensue. How the artist could make such a blunder we cannot conceive, unless he has strictly copied the original, like the minutely-correct Chinaman, who made the whole service exactly like the original pattern, crack and all, simply because the latter was accidentally there. The statuette in question represents Queen Elizabeth going to St. Paul's, to return thanks for the defeat of the Armada; it is taken from the bas-relief on the great seal during her reign. Irrespective of the anomaly just pointed out, it is a fine work of art, both as regards the high finish and the general treatment of the work. There is, also, a superb centrepiece, deserving of minute examination, by the same spirited manufacturers. C. F. Hancock has a choice, select, and really artistic, collection. Among them we admired a large vase composed of open vine-work, intended for Prince Frederick of the Netherlands; the

"Goodwood Cup" is a spirited production, and displays a more than ordinary amount of merit, but it does not equal the "Cup" for the present year just placed in the Exhibition. The latter represents the death of the young Lord Villiers, in a skirmish with some of Cromwell's troops. The incident is effectingly told. Clarendon gives us a brief but expressive outline of this episode of the Civil Wars. Lord Villiers, a young man of great personal beauty and high attainments, had, with others, got up a plot to proclaim Charles II., when he and his party were surprized by the Protector's soldiers, under Colonel Rich, at Kingston, in a lane leading from which place to Surbiton, the young nobleman was slain, after a gallant defence. The artist, Marochetti, has evidently caught the spirit of the incident in his telling and picturesque group. The outline of all the figures introduced is very masterly; the rugged veterans of the Parliamentary army contrasting well with the gallant bearing of the royal cavalier. "The young lord," says Clarendon, "having had his horse killed under him turned his back upon an old oak tree in the hedge, on the east side of the lane, and fought most valiantly with half-a-dozen assailants—two of whom he had killed, when a third coming up on the other side of the hedge, killed him with a dagger." The attitude of the young and spirited cavalier against the tree, looking right and left for assailants, is admirably portrayed; so also is the dying horse in the foreground, the limbs of which are partly paralyzed, and animation is perceptibly departing. The character of the grouping is somewhat colossal; and, in spirit, conception, and execution, is one of the most effective productions of the day. The "Hunting group" is a spirited illustration of the olden time, partly through the genius of Marochetti, and the talent of M'Carthy. The inlaid table and silver vase, in pure Etruscan, by the same contributor, is beautifully executed, and deserves commendation from its novelty, being the only one of the kind in the Exhibition. Upon the whole this contributor has displayed better taste than any other single exhibitor in the precious metal branch of industry. Keith has furnished some beautiful specimens of his silver-gilt chalices, and other ecclesiastical vessels; Attenborough has prepared a bouquet of diamonds and emeralds, which are placed in the forms of convolvuli and roses, with rubies for the buds, the whole displaying a brilliant and effective array of the precious stones. Mott's display of pencil-cases is a curiosity in its way, especially as regards arrangement; and the "Deer Stalking" of Messrs. Smith and Nicholson, designed by M'Carthy, is a spirited production. Mr. J. Angell has furnished a

few effective objects. The group representing "Arabs in the Desert" is a pleasing and poetical conception, and withal artistically treated; while that of "Sir Roger de Coverley and the Gipsies," is just as defective, the stunted tree too much heightening the figures in the group, otherwise it would have truthfully depicted the scene. The "Esop Tea-service" is an original idea, and admirably carried out, the *relievi* being minutely and delicately preserved. The introduction of enamel is somewhat of a novelty; if that be any claim to approval this manufacturer deserves it. There are, besides these manufacturing exhibitors, several others whose contributions add to the richness of the display, and indicate the plethora of wealth stowed away from the common public gaze by our great silversmith-shopkeepers; and, as they are now submitted to that ordeal for the first time, we ought to feel grateful for even a sight of them, although we may not minutely examine their respective beauties.

We now turn to the Electro-Plate and Electro-Type productions, most of which have been expressly made for the Exhibition, and are not an *omnium gatherum* of the rich old stagers of the shops and show-rooms of Birmingham and Sheffield. The baser metal productions, when tried in the furnace of fine artistic taste, if we may be allowed such a mongrel metaphor, come out much purer than their *par excellence* pure brethren. Here we escape in some measure that eternal round of grouping as an illustrative medium for almost every subject. Our designers for silversmiths seem as limited in their ideas as it is possible to conceive, or, perhaps, the silversmiths limit the ideas of the designer in order to exactly fit the limited ideas of their customers. We believe there is a grain, or half a grain, of truth in our last remark; however, we shall leave them for a moment and refresh our minds a trifle by walking round their smart, spruce, and really more elegant country-cousins. The productions of Messrs. Elkington and Mason demand our attention first, as they illustrate a really high class of art. Look at that vase; there you have originality of form, and exquisite finish of the subordinate detail. Call it what style you like—Elizabethan, though it is not strictly of that conventional class of art—it is still an object that is self-illustrative. It represents what it purports—the triumph of science and the industrial arts. There you have astronomy in Newton, philosophy in Bacon, poetry in Shakspeare, and mechanics in Watt; these several statuettes are chased boldly out and form a beautiful relief to the background or body of the vase. Let your eye fall to the base; there you will find an appropriate contrast in the shape of war, rebellion, hatred, and re-

venge, and these four figures, whose abject expression and position are typical of the predominating influence of art and science, are truthfully finished and poetically conceived. The apex is gracefully crowned with a figure of the Prince, whose name is indissolubly linked with the great world-wonder of the age. This beautiful production measures five feet in height, is elaborately finished throughout, and, altogether, it must be denominated one of the most appropriate contributions to the Exhibition. The large centre-piece is a rich design, cleverly worked out. In addition to these really tasteful objects, whose main attraction is not mere heavy weight of metal, like some of their proud and pursy *purenesses* of the metropolis, there is a singular variety of candelabra, epergnes, flower-stands, and vases, in almost every conceivable shape, and illustrative of every branch of art. Let us diverge for a moment to notice the bronze productions of these manufacturers. The statue of the Earl of Gloucester is the largest ever made by the electro process, and a very effective performance it is. The panels in the side-board are a new idea, which is capable of extension, under certain restrictions. The "Dial" is not so effective as the design might have been rendered; there is too much of contrast in the detail, which fritters away, in some measure, the conception of the artist. The wreathed circle of figures is a touch of imagination not often acquired. The copy of the well-known horse's head from the Greek is a marvel of art, and is worth half-an-hour's contemplation and study. The bust of "Peel" is rather heavy; but there is the character and expression of countenance of the lamented statesman. These productions of bronze are by electro-deposit, a branch of art to which the Messrs. Elkington may lay almost exclusive claim. Returning to silver-work, the next attractive object is in the case of Mr. G. Collis. There you will find the "Warwick Vase," the largest, we believe, ever made in the precious metal. It measures on the brim thirty-two inches in diameter, and is proportionate throughout in dimensions and height. Now turn for a moment to that table-top, and observe the chasing; you will find it uniformly consistent in character, and tasteful in design. It measures fifty-five inches in diameter, and weighs nine hundred ounces; the whole, we believe, pure silver, and is intended for some Turkish pasha. So also, we should think, is that salver close by, or it surely would never have been chased in that style for an English taste; it is too *crescentish*, too Asiatic, in the character of the design for our Western ideas; nevertheless, it is exquisitely chased and elegantly shaped. Messrs. Wilkinson of Birmingham have an elegant flower-stand, the outer

frame of silver, the inner of ruby-glass; the treatment of the design is at once original and tasteful. In the Sheffield plating productions we have some highly creditable contributions; in point of taste, in design, and finish, they are superior to the pure metal metropolitan manufactures. There appears no waste of material, and great attention must have been paid to the artistic portions of the productions. The Messrs. Wilkinson exhibit an elegant tray, some fine candelabra, and salvers and covers, which display the unmistakable marks of good workmanship. The same observation will apply to the contribution of Messrs. Padley and Parker; it is equally tasteful in form and fashion, and equally good in finish.

In the foreign departments, we have here and there some artistic productions in silver. Perhaps the most striking is in the Russian department, but we have every reason to think that it was designed and executed, or executed if not designed, in England. The fir-tree, heavily laden with snow, is a fine object for frosted silver, the form of the tree affording so much space for effect. Imagine this object on a suitable base, and immediately between the two a group of figures, comprising men and horses, and represented in attitudes suitable for illustrating a subject, and you have in your mind's eye a very beautiful composition, both in design and execution. It is also somewhat colossal. In the Austrian department there are two copies of Lebrun's celebrated pictures illustrative of the campaign of Alexander the Great, one in bronze, the other in silver, but both in high relief. We scarcely know which is the most effective; they are both fine productions of metalliferous art.

France displays her exquisite taste in the "service" of M. Oudiot. The vase in the centre is remarkably chaste and elegant, and the delineation of the game, fish, lobsters, dead birds, &c. &c., is delicately worked out. Our silversmiths should observe the effect produced by, comparatively, so scanty materials. The epergnes and baskets are equally attractive. The "*Fontaine à thé*," in the mediæval style of art, is an elaborately wrought piece of silver-work, and well deserving attention. M. Fremont has contributed a creditable specimen of silver-gilt articles; the toilet-table, the glass, and the whole arrangement of that *bijou du cabinet* executed for the Duchess of Parma, which we believe is pure metal, is a beautiful work of art, and most delicately finished. But neither in plate, plated goods, nor in electro-typing, which may be called almost an art of our own, have we anything to apprehend from the Continent, but we may learn a great deal as to taste in design, and economy in execution. There

is an English coffee-service, standing alone on the south-west side of the building, well deserving of attention, for two reasons—first, it is elegantly designed, and secondly, it is a fine electro-deposit on Britannia metal, perhaps as fine as it is possible to conceive. This contribution reflects great credit upon Messrs. Rippon and Burton.

In another department of the precious metal industry, we are equally conspicuous—the manufacture of cheap jewellery. Geneva, Paris, and Vienna are alike skilled in the production of elegant but not over-costly articles of jewellery, and each has its *specialité* in which it may be said to be supreme. We have also our *specialité*. London has its high quality of work, excellent in finish, but mostly heavy in appearance; while Paris, teeming in fancy, can supply the world with her *multum in parvo* class of metal productions. Nor is Birmingham behind the latter city in many respects; in several she is much in advance of her, and must continue to keep there, so long as she energetically concentrates her capital and labour. At the present time, you will find at Birmingham large concerns almost wholly occupied in making gold chains, and each division of the manufacture is subject to a single directing will; not as formerly, when the chasers, the engravers, the lapidaries, the enamellers, the modellers, the die-sinkers, and the gold-cutters, were working separately and independently of each other, although frequently paid and employed by a single individual. There was no working to a profitable and effective end with such scattered elements; now the principle of concentration is better understood, the adoption of it is gradually gaining ground, and the small man is quietly under the process of being absorbed by his large and capacious contemporary. To produce a single gold chain of ordinary quality, and economical in cost, great power of machinery is required, a minute division of labour, considerable activity, great judgment in the selection of the raw material, and the nicest skill in applying it. In the establishment of Messrs. Goode and Boland, the largest in England, we have seen as many as 400 hands employed, mostly girls, and all engaged, in one stage or other, in the manufacture of a gold chain. In cheapness and quality we have no equals on the Continent; nor, indeed, in any part of the world. We have seen electro-silvered and electro-gold chains sold at Birmingham, the first at 4½d. each, the second at 1s. 9d.,—both capable of lasting some time with decent care, being so well coated with the precious metals, and having the appearance of their genuine prototypes, whose value is nearly two thousand per

cent. higher. The same remark will apply to pencil-cases, and other minute articles for which Birmingham is so famed.

Directing our attention to the Exhibition, we find that Birmingham has been somewhat liberal in her contributions of this kind. In the case of the manufacturers just alluded to, we find specimens of gold chains of almost every possible make, shape of ring, and quality of material. The variety is truly marvellous, and it simply arises from altering the shape of the ring in the series of which the chain is composed. There are also specimens of other kinds of jewellery, such as broaches, pins, watch-guards, &c. &c., which are deserving of minute attention, from the fact that the Germans are competing with us in neutral, and in some instances in our own markets. In the cutting of stones, for instance, they somewhat excel us, although we have made great improvement in that respect within the last few years. Messrs. Goode and Boland have now a machine which cuts them with comparative facility, perhaps one of the nicest feats of mechanical invention on record. With the exception just mentioned, and one or two others of no great importance, the industry of Birmingham, as regards jewellery, has little to apprehend from the Continent.

In the Austrian department there are some fine specimens of glass imitations of the precious stones which greatly excel our own productions, and France still maintains her superiority in setting jewellery, and in manufacturing the various paste imitations of the diamond, and other highly-prized ornamental objects. In the manufacture of tin-foil we are equally behind France, both as regards the thinness of the metal and the colours imparted to it; consequently, we are compelled to import it from her for our best uses.

The case of Mr. John Sheldon exhibits another branch of cheap jewellery, equally as interesting as the preceding, the articles entering so generally into consumption. Here we have pencil-cases, penholders, and tooth-picks, in almost every conceivable shape; *tabatiers*, or boxes for tobacco-pipes and fusees, admirably arranged; and then succeed compound articles—such as a tooth-pick, a pen, a letter-weigher, and a seal, in one piece, and convenient for the waistcoat-pocket. The letter-balance is ingeniously constructed, being so poised that it can weigh consecutively 500,000 letters without changing its elastic and nicely adjusted properties. Ingenuity, in this instance, seems to display itself in such a variety of forms, that it is difficult to follow it. An *escritoire*, for instance, containing an inkstand, wax-taper, &c., sufficient to seal from 400 to 500 letters; steel-pens, pen-

holder, wafers, coin and letter-balance described above, almanac, blotter-pad, &c. &c.; and all within the space of a small pocket-book. Still further; there is a small instrument called a music-writer, which holds sufficient ink to make as many as 2000 dots, and yet so constructed that only one dot can be made at a time. There are, likewise, several other ingenious and useful articles in this case well deserving attention. The metal of which these articles are composed is nickel of the best quality, containing a large proportion of the pure substance, hence its silvery appearance, and more enduring quality to the general run of articles made of similar material, which seldom contain more than a small proportion of the pure metal.

While on the subject of electro-plating, we must direct attention to the invention (or rather adaptation, for the discovery was an accident rather than a design, by one of the workmen in the employ of Messrs. Elkington and Co.,) of M. Lyons, which he calls "bright electro-plating," as it differs in its results from other processes, inasmuch as the articles are produced bright from the operation, whereas, in almost all other instances, they appear dull, and have to undergo the process of burnishing. Any other merit that it may have must be ascertained by experience, the best of all teachers.

## CHAPTER X.—TYPOGRAPHY, LITHOGRAPHY, STEREOTYPE.

The typographic art of England is, upon the whole, superior to that of the Continent. Type-founding has rapidly improved since William Caxton formed an Arabic alphabet for printing the New Testament in this country. Antecedent to that period we were in the habit of importing our type from Holland; and it was not till 1720 that Caxton commenced general type-founding in England.

It is generally acknowledged that English type is made of better metal than that of the Continent, there being a more liberal admixture of antimony with the lead and arsenic than our neighbours are in the habit of using. By this means our letters are harder, and less liable to bend and wear away at the side or foot of the page, which is a great advantage to our printers. For the same reason letter-cutters pay particular attention to the "lining" of their alphabet—making the small and large letters of an equal height—so that a straight line drawn on the summit or base of the letters will touch them all, with-

out leaving one above the upper or below the under level. This precision of form in the English type is seldom observable by the public, but the experienced eye of a bibliographic connoisseur can detect its absence in foreign publications.

Nearly all the improvements in typography have been devised and perfected in this country, although the art has never received the slightest support from state patronage, like the *Imprimerie Nationale* of France, or the *Imperial Printing Establishment of Vienna*, both of which receive annually large sums for their support and encouragement. We manage things differently in this country, the State seldom interfering with private enterprise, and *prudently* restricting itself to matters of a merely fiscal nature. This circumstance reminds us of an anecdote of Canova, who visited England soon after the peace. Being shown the lion of the day—Waterloo Bridge—and learning that it had been constructed by private enterprise, the enquiring artist desired his *Cicerone* to show him some object of a public nature that the State had reared and perfected, when the latter immediately directed him to the Pagoda Bridge, then standing in St. James's Park. "Good heavens!" exclaimed the astonished stranger, "is this a specimen of State patronage? Then leave the encouragement of art to private enterprise."

We repeat that the greatest improvements in the art of typography have been effected in this country, and were we desirous of an illustration or so of this interesting fact, there is no necessity of going far or wide for it. The *Times* paper will instantly furnish one, as the progressive stages of that journal were accomplished by a series of inventions which have scarcely a parallel even in this country. The new machine, by which the proprietors of that paper are enabled to throw off so many thousands in a few hours, was brought in a great measure to its present perfect state by the unwearied exertions of a single individual, whose judgment, capital, and perseverance were more than a match for every obstacle that presented itself. The late Mr. Walter, to whose singular abilities we have alluded elsewhere, administered a sharp rebuke to those who may be termed the *impossibilities* of the age, at all times, and in all countries, the great majority. A slight sketch of the labours he left behind him will not only illustrate the progress of printing in this country, but also, incidently, enable us to estimate the differential points, if we may be allowed the term, between us and our Continental neighbours.

After a series of attempts, many of which proved abortive, Mr. Walter at length succeeded in accomplishing his ends, but sparing

neither money nor talent, whether home or foreign, in their accomplishment. The *Times* was the only paper printed by machinery for nearly two years, but its impressions were comparatively faulty, for the balls then used by printers not only deranged the machinery, but materially checked its speed. This was in 1812 and 1813. These balls were replaced by rollers, covered with skin, which left the superfluous ink contained in the seam of the cover upon the letters, forming long dark streaks, technically termed "monks." Next succeeded composition rollers, which obviated the noxious preparation of the skins. There were several claimants for this simple invention, but the honour, we believe, must be accorded to an obscure and dissipated pressman, whose memory should be held in respect by all printers, as a benefactor to his fellow-craftsmen. Out of evil there sometimes comes good, and the progress of the *Times* is a singular illustration of its truth. *It was the irregularity of the workmen* that first prompted the late proprietor of that journal to seek security in machinery; and had he been thwarted in his plans the "broad-sheet" could scarcely have been elaborated to its present magnitude, nor have acquired its present proud appellation. Through the instrumentality in a great measure of a single individual, the *Press has become the pulse of the world.* Let us suppose a Parliamentary debate in both Houses, terminating late in the morning. Thirty-seven thousand copies, say, of the *Times* are wanted, many of them sufficiently early for the morning trains, to be distributed east, west, north, and south. To set up the mass of type, before printing the paper, must be a gigantic task; to print the number of impressions required was all but impossible before the present invention was called into requisition. There are now, we believe, eight thousand copies of that journal printed in an hour, which is about double the number of any other journal printed in Europe * or America. Imagine, reader, if you have not closely examined the machine in the Exhibition, some hundreds of thousands of separate types or letters, each about an inch in length, the letter being at the upper end, encircled round a vertical cylinder, and not on a flat surface, or horizontally, as they were placed before this invention. By a simple contrivance this mass of letters are kept in their proper place, the outer edge, or, as it is technically termed, the "face of the letter," forming a compact circle of a somewhat larger diameter

* We must except the *Illustrated London News*. With a spirit worthy of its success, the proprietors of this singular production have constructed a similar machine in the Exhibition, by the same inventive engineer, which proves one of the most attractive objects in the building.

than the cylinder itself, by the projection of the rules which separate the columns, and their outside metal supporters. These are shaped like a wedge, and terminate at the "foot" in an acute angular point, the top forming the hypothenuse of the angle. By this means a gradual width is given from the bottom of the letters to their top.

The sheets for printing are placed between sets of vertical rollers and tapes, which convey them to the cylinder containing the type; the "messenger rollers," as they are called, receive the ink from the "doctor rollers," and convey it to the inking table, and after the paper has passed over it the impression issues from the machine in a complete form. This ingenious contrivance, in addition to saving time, enables 36,000 individuals to read, almost at the same hour, the news of the world; whereas, scarcely half that number would have enjoyed that privilege by the most efficient means previously in use.

Nor has even this state of perfection satisfied the ingenious inventor; Mr. Applegath is ready to put up what is called technically, a perfecting machine, which shall produce the same number of sheets in an hour printed on both sides. Such a machine warranted to produce the best work, he is now proposing to the Messrs. Chambers, with which to print *Chambers's Edinburgh Journal.*

Nor is the superiority of England in printing confined to the newspaper press, but relates to almost every other branch of the art.

M. Flachat, describing the state of printing in Paris, in 1844, remarks :—

"The progressive improvement of printing is mainly to be attributed to the employment of mechanical presses. There are at least fifty employed in Paris, which are equal to about five hundred of the common presses; and this increase has taken place without diminishing in the slightest degree, the number of printers or of hand labour. The greater portion of these presses have been supplied by English mechanicians, particularly by M. Cowper, of London; the remainder were made by M. Selligeu, but the palm of superiority must be accorded to the English."

Further on the same intelligent writer remarks, in relation to another branch of the art :—

"In another branch the English maintain a marked superiority over us—engraving on metal and on wood. It is well known that they have long excelled us in cheap engravings; the *Magasin Pittoresque* was frequently a truly English importation; most of the engravings of that and similar publications were purchased, so long as those works were continued, from the *Penny* and *Saturday Magazines.*

Several wood-engravers from England have established themselves at Paris, and diffused a knowledge of their art among us."

The art of printing has, from the earliest time, been best executed in those establishments where the steadiest and most experienced workmen are secured by good wages. Order is essential in this business; so is the greatest care, and a certain amount of instruction. From the non-observance of these important truths—notorious to all connected with the press—printing is greatly on the decline in Paris. Since ready communication between that capital and the adjacent towns has been supplied by means of railroads, the country offices have obtained, at a reduced price, the great bulk of the metropolitan booksellers' work; therefore the Parisian establishments are doing next to nothing in what is termed "the book trade." Swarms of apprentices are taken by the country masters, the larger portion of whom, when out of their time, cannot possibly procure employment; and in some offices women are employed in considerable numbers, working like men as compositors, and articled for years to receive only half their usual earnings. From forty to fifty of these women are employed in various offices within a circle of ten leagues round Paris; but, whether they will benefit themselves or their employers, by this unfeminine occupation, may be seriously questioned. In a pursuit demanding the greatest care, and the most perfect order, it must be expected that women and apprentices, however picked and culled, will exhibit work blurred with deformities, and full of lurking errors, when sent hastily to press—such as inequality in the length of pages, whites before and after chapters, too little or too great a space between the words in some of the lines, &c.

And whence has arisen this declining state of printing among our ingenious neighbours? Simply *from the irregularities of the workmen*, either striking on their own account, or energetically assisting the general outbreaks which have so fearfully decimated Paris during the last fifteen years. Capital and industry cannot endure such rude shocks; they naturally take their flight to more peaceful, and therefore more profitable, regions.

In typography, then, we have no fear of France excelling us, not even with her finest Didot and Dupont samples of type, which are got up principally for the *Exposition*, and with but slight reference to general use, for the comparatively limited means of the French printers must necessarily preclude them from using so expensive a material.

That fancy or *lithographic printing* should excel in France, while

its sister branch, typography, should be in the ascendant in England, is dependent upon several causes. First, the instruction of the respective nations has materially influenced its condition, both here and abroad. The French have devoted more attention to ornamental art than we have, and for reasons of a purely political nature, which have been already pointed out. Lithography made great progress in France during the last war, whilst in England it was comparatively in its infancy; this progress must be attributed to the excellent instruction which was extended to the French artisans by the schools of design, established throughout France. Gratuitous instruction in drawing has long been liberally given in Paris, and in all the great centres of industry in France; even the young delinquents in the capital are encouraged to colour porcelains, by the allowance of part of their earnings. At the prison, for instance, for juvenile offenders, Rue de la Roquette, a professor of painting attends seven hours a day: with these advantages, therefore, the humbler classes cannot fail to produce artists capable of executing tolerable designs for most purposes, particularly as they are stimulated by the pressure of daily want.

There is, moreover, a large body of artists whose works are refused at the National Exhibition, and who have little chance of obtaining a livelihood by their professional pursuits, therefore offer their services to lithographers, manufacturers of fancy articles, tailors, milliners, &c., in the hope of turning a penny even in these humble avenues of art. And so great is the competition among these needy practitioners, that when a novel design is to be executed, a rough sketch, accompanied with instructions, is given to half a score of them, with the express proviso that none but the drawing chosen out of the lot shall be entitled to the stipulated reward. By this supply of skilled labour exceeding the demand, the capitalist possesses means, known in few cities except Paris, for purchasing a very superior model at a very low price. Need we wonder, then, that the French *modiste* and *coupeur*, with such a phalanx of art, should dictate the laws of fashion to the whole civilised world?

The lithographic press of Paris supplies an immense quantity of gold, silver, and coloured borders, corners and centres, for boxes of almost every description appertaining to the toilet-table of the fair sex. On paper, on glass, and on every material connected with the delicacies, and even the luxuries of life, the best pictures and devices are imprinted by the lithographer's art. The French, certainly, have attained an excellence in this branch of industry, far beyond ourselves, and also beyond all Europe, although the materials used by them are

cheaper in England than in France. It is the excellence of art, then, that has obtained for the latter so marked a supremacy in lithography; and to such an extent is it practised in Paris, that England alone imports £40,000 worth of lithographic articles annually, according to the authority of M. Dupin.

Partly, however, by importing the skilled lithographers of Prussia and France, and partly by an improved native taste, this art has received a decided impulse in this country, improved presses with steam power are also being applied, and on one of our visits to the machine department we observed the press invented by Mr. Maclure, of the firm of Maclure Macdonald and Macgregor, doing its work very satisfactorily.

*Stereotype* was invented by Lord Stanhope, though the French printers have set up a claim in favour of the late Mr. Herhan (a German), formerly printer in the Passage Lemoine, Rue St. Denis, Paris. The latter certainly invented *a system* for stereotyping, which consisted in composing the pages with hollow-faced, instead of projecting types, the result of which must have been a continual change of the materials employed. *The method*, therefore, which has always been employed by the stereotypers of all countries, remains very nearly the same as it was when presented to society by Lord Stanhope. The art was imported into France by James Ferguson, who had assisted his Lordship for several years in his amateur office; and the first French *stéréotypie* was established in the office of Mr. J. Smith, an English printer, formerly residing in the Rue Montmorency, and afterwards in the Rue Fontaine-au-Roi, where the office still exists, under the direction of his widow and sons.

Thus, if in fancy or decorative printing our neighbours are superior in practice, invention, and that good taste which can be mastered only by experience, we have a just claim to inventions of the greatest practical utility in that branch of the art more generally required.

On turning to the contributions from the continent, in this interesting branch of industry, we are particularly struck with the numerous specimens from the imperial printing establishment at Vienna, and from the typographic establishment of M. Dupont of Paris. They are alike instructive and important, and will receive that careful and minute investigation which the practical minds of this country never fail to bestow upon everything that has an immediate bearing upon their craft. First, as to the contribution of M. Dupont. He claims a new invention of stone-engraving, termed litho-typography, which can be effectually applied to the reproduction of old or new books,

manuscripts, tables, stamps, &c. By means of a chemical process he can produce on stone the pages of a book, or the engravings required for new copies, and draws them off by the common lithographic press. Old and rare editions have already been renewed by this process, which has rendered great service to the arts and sciences, as a larger number of libraries can now possess them. This process, or one nearly resembling it, made some noise a few years ago in this country under the name of Anesthetic Printing, but with us it never made much way. M. Dupont has, likewise, contributed a further novelty, equally deserving of attention. He calls it *stereotype stone*, by which he can produce engravings that will bear comparison with those produced on copper or steel. M. Dupont has applied this invention, as he states, successfully to the production of engravings for insertion, in the text of books. Senefelder, the inventor of lithography, employed acids to produce reliefs on calcareous stone, but it is known that he was unsuccessful. M. Paul Dupont has taken up the same idea, and worked it out to the present results. By a strong pressure, with the aid of acids, he can produce reliefs on stone, which are capable of leaving transparent impressions almost equal to water-marks, but at a much more economical rate. The lithographic presses of this ingenious printer are worked by steam. By means of a simple piece of mechanism the ink is distributed over the rollers, and only the upper part of the press is put in motion, which saves the men a great deal of labour, and enables them to draw off the impressions more cleanly and quickly than by the old process. This invention was patented in 1850. The specimens of printing, of lithographic engraving, and of the productions of the preceding inventions, in the contribution of this intelligent foreigner, as we have already remarked, are entitled to peculiar attention. They are to be found in the south-east compartment, on the ground-floor, in the French division.

On the opposite side of the building, and immediately abutting on the great eastern nave, the reader will find the Viennese contribution, with a very intelligent gentleman to explain its contents. The first novelty that strikes the eye are the productious of *chromo-lithography*, which transfers a coloured painting to paper by a series of stones, there being a separate stone for each colour. There you will see the impressions in single colour, and the process by which the various colours are combined. The original paintings are hung in juxtaposition with the copies, so that you may judge of the excellence of the process which produces a copy fully equal, in appearance, to the original. It is a beautiful invention, and has already been practised

in this country to a limited extent by Messrs. Day and Haghe, Mr. Maclure, and other lithographers. Mr. David Roberts' picture of the Siege of Jerusalem in Lithotint, as the art is denominated in this country, forms a contribution to the Exhibition in the Fine Art section, as a specimen. The next phenomenon in the Viennese contribution is the galvano-graphic process. The picture is first painted on a prepared copperplate, which is then placed in a galvanic apparatus, and the result is an engraved plate, which only requires a little touching up. The impressions are printed from this plate, so that the original painter and engraver are one and the same hand, which obviates many difficulties, especially the inferior genius of the engraver, which frequently depreciates the finest efforts of the painter. The next remarkable novelty in the collection are the specimens of *chemitypie*, a new discovery in the art of engraving. The invention is due to M. Piil of Copenhagen, who has been enabled to perfect it in the imperial establishment at Vienna. By this invention he can obtain copperplate impressions as easily as those of wood, and upon precisely the same principles—from a raised surface. These impressions are produced at a printing-press, which, according to the statement of the imperial authorities, accelerates the production fifty-fold, and proportionately lowers its cost. The process may be thus described :—A zinc-plate is prepared and covered with an etching ground, then etched, after which the surface is covered with an easily fusible and negative metal, which sinks into the hollow parts produced by the etching, the remainder of the ground being scraped away. The surface of the plate is again etched, until the design becomes as strong a relief as is required of a woodcut. The plate is then reproduced by a galvanic process as often as required, so that thousands of copies can be easily printed each equal to the first impression.

We now turn to the typographical branch of this exposition. Here we have presented us a pedigree of all the known alphabets in the globe, from the most remote known period, up to the present day, stretching back even to the Phenician characters, and embracing in their living representations, those of Japan and China. From the Chinese and the Koreanic characters on the one hand, and the African hieroglyphics, which are followed by the Phenician characters on the other, the Viennese *savans* arrive at the conclusion that they have discovered the basis of all alphabets, although there are numerous ramifications of the latter, which may be traced to the characters used at the present day. We shall leave this recondite question to others, and content ourselves with calling attention to "Auer's" collection of

the Lord's Prayer, printed in 608 languages and dialects, in Roman type; the second section containing 206 languages and dialects, all of which are printed in the characters peculiar to each language. We must now direct attention to a series of electro-galvanic objects, which clearly demonstrate the superior power of electro-metallurgy, where the multiplication of numbers is desired, whether the former be flat, raised, or sunk, on the surface. Look at those fossil fishes. The originals were incrusted with gutta-percha. After the crust was removed the fossils were prepared, and placed in a galvanic apparatus, by means of which a copy was obtained, without the aid of the draughtsman. The process of *typometry*, or the method of calculating and measuring the space taken up by each letter, is also deserving attention. By the aid of typometry we can calculate the space of a manuscript when printed; in addition to which, all tabular matter may be easily arranged, because the space of each column can be estimated to the nicest precision, a matter of great importance to printers. The translation of the Japanese novel is a typographic curiosity, which can rarely be equalled; and the gutta-percha moulds may suggest an idea or so to the practical mind of some value. This contribution, perhaps, on the whole, is the most instructive of any that has arrived from the continent, and Austria has paid us a high compliment in so carefully preparing it, and entrusting it to our good keeping. It is somewhat singular that the most illiberal and despotic forms of government, as the Austrian administration is so unjustly called, should cultivate the typographic art, and diffuse that cultivation to a greater extent than any state in Europe, not excepting France, which, *par excellence*, assumes to take the lead in such matters. Yet, so it is, and it furnishes one among the many proofs, that mankind are more led away by the show than by the reality of things, especially when their political feelings are concerned.

We shall now conduct the reader to the typographic specimens of our own countrymen. In the first place, he must be struck, if he have the least practical experience, with the beauty, the finish, and the everyway superior condition of our type. The reasons why we have obtained this superiority have already been given, and it is not very likely, in these competing and spirit-stirring times, that we shall easily lose it. The cases of type contributed by Messrs. Beasley and Co. and the brothers Figgins, differing slightly from each other, cannot possibly be surpassed in quality of metal, or in the form of the letter; to our mind their contributions present one of the most interesting phenomena in the whole exhibition, assuming it to possess the qualities which we

have freely, but we believe justly, accorded to it. What can be more interesting than the finest form of that little instrument which gives wings to our thoughts, and permanent impressions to our ideas? Apart from any indulgence of this nature, it is really worthy of minute examination. So is that of Duncan Sinclair, which comprises a singular variety of typographic objects. The Messrs. Caslon have furnished specimens of caligraphic type, and colours for ornamental printing; so, also, have Ferguson Brothers of Edinburgh, of printing type, both of which are well worthy of attention. Figgins' specimens of type, in addition to the forms noticed above, of the raw materials, of the mould and matrix, and of stereotpye and polytype, are really a study, and a highly interesting one. Novello's musical types, and his sketch of the method of printing music from moveable types, should not be lost sight of, as it clearly indicates that a still greater improvement may still be effected in that branch of printing. Bradbury and Evans have contributed a fac-simile of their general style of printing, where engravings are introduced, which is highly creditable to their industry, although there is no particular novelty in it. Millar and Richards of Edinburgh have furnished a beautiful specimen of type, the smallest, they say, ever manufactured in this country. They have accompanied their specimen with an impression of Gray's *Elegy*, simply to show the clearness and precision of the type. It certainly is a very beautiful specimen of typography. The whole of the *Elegy* is contained in two columns, three and three quarter inches deep. G. A. Hughes' machines for enabling the blind to write, calculate, and copy music are deserving of peculiar attention, as they indicate the humane and benevolent direction which instruction is taking; and the same remark may be applied to Dr. Foulis' tangible ink for the blind, producing raised characters on paper. Mr. Gall's typhlograph is a kindred invention, as it teaches the blind to write; so, also, are the types by which the sightless are enabled to correspond with each other. The Phonetic Testament may amuse those who take an interest in being eccentric in the forms by which they express themselves, or receive instruction and amusement; to others it will be a mere abracadabra. Arliss and Tucker's application of printing to tinfoil is a useful introduction to this country, and is ingeniously illustrated. On the whole we have nothing to apprehend in this branch from our friendly competitors; but, on the contrary, we have a great deal to congratulate ourselves upon.

## CHAPTER XI.—MACHINERY, &c.

Upon entering the department of machinery in motion, the casual visitor is in some measure amazed and bewildered by the continued whirring and clatter which surrounds him in every direction. This scene, for the first time presented to his view, will probably appear little better than one of disorder and confusion; but after the first impression is worn away, he will quietly and leisurely examine the several operations which are being carried on. There he will be attracted, perchance, by the process of printing, which is carried on by presses as varied in their form and mode of work as it is possible to conceive—from the old hand-press, producing but a few score copies per hour, to Applegath's last improvement, producing as many thousands in the same space of time. In another direction may be seen the lace machine, with its thousands of little bobbins, carried, as it were, by magic, through the warps; and, in immediate proximity, the manufacture of bobbin-net may be observed, equally marvellous, and equally surprising, to the uninitiated eye. The machinery for the preparation of flax, with all its complicated relations, may next meet his view, and close by a similar series, for the production of cotton yarn and silk warps; varying, it is true, in their structure, and in their principles of action, but still wonderful to the general observer. Then we have the power-loom, for the conversion of yarn into a fabric, and for the transformation of raw wool into cloth; but, above all, there is the beautiful Jacquard machine, producing its truly wonderful results—a monument of man's intuitive sagacity. And all these machines are working with the greatest precision, and each contributes its quantum of noise to the general din; but this scene, which seems confusion to the casual and non-practical observer, is order and regularity to the mechanician, whose practised eye can measure all their movements, and instantly detect their slightest irregularity. While we are looking to the result of a machine's producing power, he is probably watching with the eye of an anatomist, the operation of the means.

But the principal source of attraction to the practical mind will be the numerous plans for producing motion by steam, as in this class of machinery the display is singularly varied. Here we have steam-engines of every size, from the locomotive of 1000, or the marine engine of 700 horse-power, to a model standing upon a shilling for a foundation plate, and of every conceivable form. The Oscillating,

the Trunk, the Pendulous, the Beam, the Horizontal, the Vertical, and a whole army of Rotatory Engines, confront us in almost every direction. The latter form of engine, indeed, seems working its way into general use, which is much to be desired, seeing that the work of a moderate sized factory can be performed by one of that class, not occupying, perhaps, more space than an ordinary-sized hat-box. The Rotatory Engine has worked its way into general notice of late years, against every possible objection; and, although it cannot be said to work so economically as its Reciprocating rival, still it has several advantages of a compensating nature. It is not long since that the radial motion, and the consequent unequal wear and tear of the rubbing surfaces, were looked upon as an inherent and irremovable defect in the system of the Rotatory Engine; these difficulties, however, have been removed, and no longer constitute what is called a common defect. Again, it was shown, to apparent demonstration, that the whole system is radically wrong, and consequently that success would be an impossibility; but these prejudices, like others of a similar nature, which are invariably entertained against all new inventions, are giving way before the palpable truths of experience, and it is now generally acknowledged that the difficulties to be overcome are simply of a mechanical nature. It is fair to presume, therefore, that the Rotatory Engine will take the place of the Reciprocating Engine, as its advantages are so obvious: in the first place, it occupies less space, consisting of a less quantity of material; and, in the second place, it can be purchased for much less money, a matter of very great consideration as regards the choice of machines. In marine purposes it will be especially advantageous, as the saving of weight is tantamount to increasing the size of the ship; and in some of our large steamers this saving would amount to from 100 to 200 tons, itself a profit upon the whole undertaking. Its application to the screw-propeller would be equally effective, and equally advantageous. In fact, the Rotatory principle has been the pet object of speculation for the last eighty or ninety years; for it is clear that Watt, in his first patent, dated 1768, made a provision for its application, although upon subsequent trial it was not found successful. Several plans were patented by Watt for the same purpose, but the difficulties proved too great even for his gigantic mind, although he could devise a Reciprocating Engine, and in so comparatively a perfect state that subsequent engineers were left little to accomplish. The only improvements, since the days of Watt, in the Reciprocating Engine, have been in the construction, but not in the principle, for in cases where

the per centage of work has been brought to the highest point, it has only been by carrying out the principles which he prominently urged. The working of steam expansively, for instance, was provided for by Watt. His mind saw the saving to be effected by not allowing the steam to enter the cylinder during the whole passage of the piston from one end to the other, but by stopping it when the latter had completed a certain portion of its passage, the remaining portion being performed by the expansion of the steam already within the cylinder.

It is acknowledged that the performance of the Cornish engines is more effective than many others; therefore it may be as well to notice their peculiar power, as others have the same means of realising similar results. The extra amount of power obtained by the Cornish engines may be mainly attributed to two causes—first, the comparatively high price of fuel; and secondly, the economical system of mining. We shall leave the first cause, which is dependent upon several contingencies, equally determinable; the second requires a word or two of explanation. Mining operations being generally speculative, it is essential that the mine owners should proceed upon the most economical basis; therefore engineers usually guarantee a certain amount of work for a given consumption of fuel, when they fit up their engines; and this guarantee necessarily generates a great deal of emulation amongst them, as he who promises and performs most is sure to obtain the largest amount of patronage. A registry of the performance of different engines is also kept, so that each engineer is enabled to know what the other is doing; and, as a consequent result, the expansive principle is carried to its ultimate practical limit. An ordinary engineer, not accustomed to such restrictions, would not pay so much attention to details, which have a most important bearing upon the economical working of an engine. It cannot, perhaps, be expected that engines in our factories should be worked so economically as they are in Cornwall, since we cannot so well apportion the work to the capabilities of the power; still, much more might be effected than is at the present time, were we to adopt a similar system of registration. The manufacturers of engines would, most likely, object to such a test, although in the long run they would gain as much as the public by the system. Why should a warranty be given with an engine in one place, and not in another? Why should horse-power be such a nominal, meaningless term as it is at present? Engineers may adopt what standard they please, but let it be understood; so that in purchasing a steam-engine the purchaser may know precisely what

power he is likely to obtain, which certainly is not the case at present.

The expansive method of using steam cannot, however, be conveniently employed to a great extent in factories, so long as their engines have but a single cylinder, as it would produce great irregularity of motion, and that defect can only be removed by using two cylinders, one large and one small, the steam being allowed to enter the small cylinder from the boiler, and thence passing to the larger one, where it must be left to expand. This plan was adopted by Woolf, towards the latter end of last century, and has been more or less acted upon ever since. The Messrs. Joyce of Greenwich exhibit one of their Pendulous Engines, which works upon this plan; and, for compactness and simplicity of arrangement, there is little to be desired in its construction. The Messrs. Penn, of Greenwich, also, exhibit specimens of their superior work in Oscillating Engines, which are now somewhat extensively employed in river and sea-going boats; and the symmetry, the exquisite finish of the different parts, their general arrangement, and the smoothness and regularity with which they perform their work seem to preclude any great advance in the manufacture of that class of engine. The Oscillating Engine, indeed, is rapidly superseding the side-lever engine, and may be regarded as the greatest innovator since the days of Watt.

There is also another element worth noticing, while estimating the improvements effected in machinery, as it affords a satisfactory proof that no one section of industry can improve without extending a certain degree of improvement to others. All, indeed, proceed *pari passu* on the path of improvement. The superior workmanship of the present day must not be attributed solely to the improved skill of our workmen, but rather to the improved method of making their tools. The construction of an engine, therefore, is due to the perfection of the tools quite as much as to the skill of the workmen. The accuracy and perfection of tool-making has attained its present state through the intelligence, principally, of the Messrs. Whitworth of Manchester, whose contribution of lathes, boring-machines, dies, taps, &c., will be viewed with the deepest interest. This enterprising firm has also rendered a still more important service to the engineering interests—that is, to the public at large. They have attempted, and partially succeeded in introducing, a general system in the size and form of screw-tools, boring-bits, &c. &c., which must practically prove of great advantage. For instance, each engine-maker, at the present time, has a set of screw-tools of his own peculiar design, or those

which may have been handed down to him, but differing with the tools of other makers; whence it follows, that the maker of an engine ought always to repair it, but as that is frequently impracticable, the expense attendant upon it is increased enormously—for strangers with different tools, however skilful, cannot perform the repairs so economically as the original maker. This great evil is being remedied by the enterprising firm in question,—and may they be wholly successful.

In the locomotive department, the Great Western and North Western Railway Companies are exhibitors of two fine specimens of their heavy express engines. Still the reflection arises, on looking at these ponderous machines, that there must be something radically wrong in a system in which the engine has to exert more than one third of its power to draw itself; and as the engine weighs with its tender, when in working order, more than fifty tons,* the required speed can only be attained by a fearful expense of wear and tear of the permanent way, and of power expended in drawing the dead weight. It would almost appear that railway companies had raised a monster which eventually must work its own destruction. Messrs. Adams and England, the principal promoters of the light locomotive system, exhibit respectively engines of a peculiar construction, which attract a great deal of attention. Appold's centrifugal pump is also an object of considerable attraction, simply, we believe, from the enormous quantity of water which appears to be elevated. There are several pumps in the machinery department of this kind exhibited; and the simplicity of the means, as compared to the results obtained, are really surprising. The broad principle upon which these pumps operate may be thus described. A series of vanes is fixed upon a spindle, and caused to rotate very rapidly; water is then allowed to enter at the centre of the vanes, which is instantly thrown off at the periphery by the centrifugal force. But in what position does the common pump stand at the present time, and what is left for us to improve upon in connection with it? In the first place, there is no means of getting rid of the weight of water to be lifted—that is a constant quantity in any machine. For instance, if a ton of water has to be raised fifty feet, the power required to effect this cannot be expressed by a lower equivalent than 112,000 lbs. raised one foot high.

* The engine, when in working order, weighs 35 tons; the tender, with water and coke, weighs 17 tons 13 cwt.; making a total of 52 tons 13 cwt. It is capable of taking a passenger train of 120 tons at an average speed of sixty miles per hour upon easy gradients.

The next point is friction in the machine itself, which is variable. In the common pump, however, it is exceedingly small. Thirdly, its durability. We know, from experience, that the common lift pump will go on working for years with scarcely any attention, and a few shillings for new leathers will generally set it in order again; therefore it does not appear that we shall be very large gainers by adopting centrifugal pumps, the velocity of which increases the friction to such an extent, that the durability is reduced to the minimum. There is one point, however, worthy of note in raising water—that is, to keep it constantly moving, otherwise the inertia has to be overcome each time it is put in motion. This, certainly, is a defect in the single-barrel pump, but may be partially overcome by the use of three or four barrels, or air-vessels, &c.; and if centrifugal pumps possess any particular advantage in this respect, it will soon be made manifest and adopted.

The "Great Hydraulic Press," used in raising the tubes of the Britannia Bridge, is one of the most marvellous among the phenomena of the machinery department. This machine raised the tubes from the level of the water to their permanent position, a height of 120 feet. Imagine two strong cylinders of cast iron, one larger than the other, communicating by a pipe, in which a valve is placed, opening from the small towards the large cylinder. At the top of each cylinder is a water-tight collar, in which is inserted a cylindrical rod, fitting close, and which descends into the cylinder. These rods are a little less in diameter and in length than the cylinders, so that when they are sunk in them a space will remain around and below them. The large rod is called the "ram," the small one the "plunger." Suppose the ram let down in the large cylinder, and the plunger raised to the top of the smaller one, both cylinders and the communicating pipe being filled with water, if the plunger be then pressed down in the small cylinder, it will displace a certain body of water, which will force its way through the connecting pipe into the large cylinder, where the ram will naturally rise to give it space. The power exercised by one rod on the other must therefore depend upon their relative magnitude. Thus, if the ram be ten times greater than the plunger, it follows that the tenth part of the former will fill a space equal to one part of the latter, or, in other terms, to raise the ram through a height of one foot, the plunger should be moved through ten feet. Each time that the plunger is raised to repeat the stroke, water is drawn into the lesser cylinder from a reservoir, on the principle of a common pump, and during this operation the water driven

into the large cylinder cannot return, as the valve in the connecting pipe prevents it. To estimate the force exercised, we have simply to consider that the pressure produced on each square inch of the plunger will produce an equal pressure on each square inch of the ram. This results from the fluidity of the water between the plunger and the ram; and if the ram, upon the preceding supposition, be ten times greater than the plunger, it follows that a pressure of one ton exerted by the latter will produce an upward pressure of ten tons upon the former. Such is the general principle of the hydraulic press, which is now applied in so many ways, and to such useful purposes. The weight and bulk of the above press is as follows:—The great cylinder is 9 feet long, 22 inches internal diameter, 10 inches thick, and weighs 15 tons. It is made of cast-iron, and the aggregate weight of metal required for casting it was upwards of 20 tons. The greatest weight lifted by the press was 1,144 tons, but it was capable of raising 2,000 tons. The quantity of water injected into the great cylinder, in order to raise the "ram" six feet, was 81½ gallons; and in the operation of the machine each lift of six feet occupied from 30 to 45 minutes. This enormous press was made at the Bank Quay Foundry Works, Warrington.

The Nasmyth steam-hammer, another of the gigantic wonders of mechanism, is close by, and attracts general attention. In all great iron-works this powerful help is to be seen at work. We observed two at work in the foundry of Messrs. Fox and Henderson at Smethwick, and one at Messrs. Thornycrofts at Wolverhampton, and the power of this effective piece of mechanism must be seen to be appreciated. The wonder is that a machine subject to such heavy concussions will admit of such nicety of adjustment in action, without apparently the slightest derangement, and be capable of either giving a blow of several tons weight, or of simply and gently cracking a nut. This nicety of movement in so ponderous a body is effected by the combined action of gravity and the pressure of steam. For heavy work this hammer is found almost indispensable, but when the old tilt-hammer can be used effectually it is generally preferred, the blow of the Nasmyth upon the bloom being too great, for when the metal prepared by it is beat up and submitted to the rollers it is frequently found to contain too much dross. The effective power of this instrument may be inferred when we state that it can give from 70 to 140 blows per minute, the force of the blow depending upon the space described by the hammer. If the hammer be lifted 10 inches, it gives a force of 1000 pounds, if 20 inches, the force is 4000 pounds. The principle on which the

hammer works is simply this—a cylinder is placed above the hammer and a piston-rod is brought in connection with the latter by passing through a stuffing box immediately below the cylinder. The main difficulty was how to prevent the concussions of the hammer from injuring the piston, and this was effected by packing the end of the piston-rod in the hammer between pieces of wood, and keying it down, the wood being sufficiently elastic for that purpose.

The press used in testing the cast-iron girders of the building here is also worthy of notice. The long girders, supporting the roof over the nave, which are composed of wrought-iron, did not require to be tested so severely as the cast-iron. The pressure on the latter was not applied simply to the middle of the girder, but at two points, each about one-third of its length, which was found sufficiently effective.

The turn-tables, the cranes, and the models of machinery for heavy work are numerous and singular, and in the aggregation afford a truly instructive *coup d'œil* to the spectator.

Messrs. Hick and Son exhibit a model of their hydraulic press, on a reduced scale, with specimens of its effective power in the shape of punched pieces of cold iron. There are four cylinders in the original machine, each weighing two tons, and their combined action is capable of producing a pressure of 2500 tons. The advantages of the compound cylinders over a single one of even greater power are these—the four may be either worked together or separately, and that much better castings can be obtained from the small than the larger kind, as a single cylinder of equivalent power would weigh twenty tons, whereas the aggregate weight of the four is only sixteen. The planks of cold iron, punched by this press sufficiently attest its power. For 1½ inch thickness, a pressure of 700 tons is requisite; for 2 inches, 950 tons; for 2½ inches, 1250 tons; for 3 inches, 1600 tons; for 3½ inches, 2050 tons, and, probably, as a maximum of its power, a hole of eight inches in diameter has been punched through a plank of cold wrought iron, of 4 inches in thickness.

We have already alluded incidentally to the effective tools of Messrs. Whitworth, and their important bearing upon our mechanical excellence; we shall now simply call attention to the "Micrometric Apparatus" of this firm, which is one of the most original contributions to the Exhibition. It is the first attempt yet made in the mechanical world to establish a uniform standard of magnitude in machinery, so that that uniformity may be as well understood as the uniformity of language or numeration. Suppose two metallic surfaces, by friction or otherwise, are made so plain and smooth, that when laid upon one

another every part of the surfaces are in equal contact; and then suppose a stratum, inserted between them, composed of particles of air which act like perfectly smooth rollers, the surfaces will then move in contact with each other in the most easy manner, owing to the lubricity of the air. If the air, however, be excluded by pressure, the contact becomes so complete that it is difficult to overcome. These surfaces are used as tests to other plane surfaces, and with these are tested the ends of a standard measure of metal, which is placed in a horizontal metallic bed, one end bearing against a metallic pin, while against the other end another metallic pin is urged by a screw; and if this metallic bar suffer a change in its length, amounting to even the millionth part of an inch, by temperature or otherwise, that change is instantly perceptible. And thus—the pin which bears against its extremity is moved by a screw, having ten threads to the inch. On the head of this screw is a wheel, consisting of four hundred teeth, worked in a worm by another wheel, the rim of which is divided into two hundred and fifty visible parts. As each thread of the screw corresponds to one-tenth part of an inch, each tooth of the wheel upon its head will correspond to the four-thousandth part of an inch, and each division of the wheel connected with the worm will correspond to the millionth part of an inch. A change in the position of the wheel attached to the worm through one of the two hundred and fifty divisions, is therefore rendered sensible at the point of the screw which bears against the standard bar, to the millionth part of an inch. The accuracy of this micrometric apparatus was proved by placing in it a standard yard measure, made of a bar of steel, about three-quarters of an inch square, having both ends perfectly true. One end of the bar was placed in contact with the face of the machine; at the other end a small piece of flat steel was interposed between it and the machine, whose sides were also made perfectly parallel. This was termed the contact-piece. Each division on the micrometer represented the one-millionth part of an inch, and each time the micrometer was moved only one division forward the experimenter raised the contact-piece, allowing it to descend across the end of the bar simply by its own gravity. This was repeated until the closer approximation of the surfaces prevented the contact-piece from descending, when the measure was completed, and the number in the micrometer represented the dead length of the standard bar to the one-millionth part of an inch. Eight repetitions in a quarter of an hour produced the same results, there not being a variation of one-millionth of an inch. This method was termed the "system of proof by the contact of perfectly true surfaces

and gravity." By the application of this instrument standard gauges for axles, taps, and other parts of machinery, which it is desirable to maintain uniform, is constructed; and so minute is its operation, that magnitudes can be estimated that do not exceed the one-millionth part of an inch.

Robinson's patent steam cane mill is a powerful piece of machinery and of exceedingly simple structure. It consists of a steam-engine and sugar-cane mill, with their connecting gear, and so constructed that they are combined upon one horizontal plate, and form but one machine. There is no particular novelty in any of its parts, but the combination and simplicity of arrangement of the parts render it an object of attraction to the practical mind. The engine is constructed on the direct-acting principle; the mill on the three-roller horizontal plan, and the connecting gear is on what is called the double-geared plan. The iron base-plate obviates the necessity of masonry or carpentry foundations and structures, usually required, as it rests simply on the ground-floor, and the parts of the machinery are easily fitted to their places in the plate, which is a great and economical desideratum. These engineers have kept the right principle in view, if they can only practically carry it out—"to obtain from a given weight of cane the greatest quantity of juice in the shortest time, and with the lowest consumption of fuel."

The Messrs. Sharp have contributed a specimen or two of their gigantic structure of machines which astonish, naturally, the uninitiated spectator, and even surprise those who look a little deeper into such matters. The lathe for turning the tires and bosses of railway wheels is a remarkable piece of machinery; it consists of two face-plates, each seven feet in diameter, and capable of being placed at a distance of nearly ten feet apart. A pair of wheels can be mounted in this lathe, provided they do not exceed seven feet in diameter, and rest upon an axle of nine feet six inches in length, one wheel being attached to each face-plate. Self-acting apparatus is provided, by which the two tires can be bored at the same time, or one may be turned while the other is being bored or bossed. A man at this lathe can do as much work as two men at one of ordinary construction. The planing-machine of the same firm is also worthy of attention. By this construction a mass of iron six feet long, and three feet five inches in width and height, is planed by moving along a travelling table, whilst the tool which cuts it is fixed upon a cross slide, and so arranged that the machine itself, being once put in motion, causes the tool to cut either horizontally, vertically, or at any intermediate

angle, without the interference of the attendant. The cotton spinning machine of Messrs. Sharp is, also, deserving of notice, from the simplicity and economy of its arrangement.

Messrs. Watkin and Hill's sectional models are amongst the most instructive apparatus in the Exhibition, and justly elicit a great deal of admiration. These models reveal the internal structure of engines, and exhibit the *modus operandi* of their movements. The engine is represented as cut through by a longitudinal vertical plane, exhibiting on one side its internal form, and on the other its internal mechanism; the pistons, valves, slides, levers, and other moving parts, represent exactly those motions which they have in the real machine. The motion, in this instance, is produced by mechanical contrivance; while in the working machines it is produced by the action of the steam. There are three models; one of them represents a marine engine, another a locomotive, and the third a stationary condensing low-pressure engine. Let us describe the mechanical movements of one of these model steam-engines. When the piston begins to descend, the slide which admits steam from the boiler to the top of the piston is open, so also is the passage which communicates between the bottom of the cylinder and the condenser, hence the piston is urged downwards by the steam against a vacuum. When the piston arrives at the bottom of the cylinder, the slide which governs the admission and escape of the steam shifts its position, so that the bottom of the cylinder is put in communication with the boiler, and the top with the condenser; the piston being driven upwards by the pressure of the steam under it. By observing the condenser and the passages leading thereto, the spectator will see the working of the air-pump, and its valves opening and closing, by which the water and air are drawn from the condenser and thrown into the hot cistern. The action of the hot and cold water pumps, the parallel motion, the governor, and all the internal arrangements of the engine, may also be seen, which will impart an instructive lesson to the attentive observer.

But the greatest variety of engines is in that section which is devoted to marine purposes. There the ingenuity of the mind seems stretched almost beyond its natural endurance,—so singular, apposite, and novel, are some of the specimens, and so contrary in all these qualities are others, especially amongst the few foreign contributions. What a revolution has been effected in the construction of machinery, as applied to marine purposes, since the first steam-tug plied on the Thames in 1804, or Fulton traversed the mighty waters of the Hud-

son in 1808! All is changed, but the material and the mode of working it up, and even that has experienced its share of change. The Atlantic is now bridged over by means of the steam-engine, and it scarcely takes any more time to traverse the mass of waters that welters between us and the new world than it did to go from London to Manchester, some sixty or seventy years ago.

The marine engine was usually constructed in the following manner up to a comparatively recent period. The paddle-shaft, extending across the vessel, was kept revolving by two cranks placed at right angles to each other, so that when either of them was at its dead point the other was in its most efficient position. Under each of these cranks in the hold of the vessel was placed an engine, consisting of a vertical cylinder in which worked a steam piston; the rod of this piston acted upon a parallel motion by which its force was transmitted to a pair of beams, placed one at each side of the engine in its lower part, the other end of the beams being connected by a rod with the crank. The connecting rod was presented upwards. The two engines were precisely counterparts of each other, and placed one at each side of the vessel under the cranks, a gangway being maintained between them for the convenience of the engineer. Nothing can more strikingly exhibit the total change that has taken place in the structure of marine engines, than the fact that there is not a single engine in the Exhibition constructed like the one just described. The Messrs. Maudslay are the largest and most effective exhibitors in this class of machinery. One of their machines is a double-cylinder engine, consisting of two steam-cylinders, each of half the area necessary for the intended power. These two cylinders, placed as close to each other as circumstances will allow, form a single engine; the piston-rods are connected together by the horizontal extremities of what may be called a T shaped cross-head, and move up and down simultaneously with it and with each other, so that the combined action of the pistons is directed upon a single crank on the paddle-shaft. By this arrangement the simultaneous ascent and descent of the two pistons in the cylinders causes the cross-head to move perpendicularly up and down between the guide-bars, thus raising and depressing a slider with the connecting rod, the latter giving a rotatory motion to the crank and paddleshaft. The steam is admitted to and withdrawn from the cylinder by a single slide valve common to both, through a pipe in the usual way. There is also a narrow passage of communication which enables the steam to pass freely from one cylinder to the other, for the purpose of equalizing the pressure. This construc-

tion of engine is more adapted to the larger class of vessels, as it produces a greater amount of steam than has been commonly available in a given area on shipboard, and also obtains a greater length of stroke and connecting rod in a given height than is gained in a direct-action engine by other means. The advantages obtained by this structure of engine are more direct action on the crank, economy of space and material, and simplicity of construction. The same firm also exhibit other forms of construction in steam-engines applicable to marine purposes, some of which but slightly vary from the one described; but their double-piston low-pressure engine, which is more particularly applicable to river navigation, is well deserving of notice, as several have been constructed for the shallow waters of the Rhone, the Indus, and the Sutlej, where they have been found highly useful and effective. The screw-propeller of Messrs. Maudslay will likewise attract attention, from the ease with which it may be applied as an auxiliary power where steam is required; and especially as the action can be suspended when the vessel is under weigh, and without interfering with her sailing or steering.

Mr. Atherton, chief engineer of the Royal Dockyard, Devonport, exhibits an engine of an original form, for marine purposes. It is applicable, according to the inventor's statement, of being either applied to the paddle-wheel or the screw-propeller. The intention is to simplify the construction of the marine sway-beam engine, and, as compared with the ordinary construction of side-lever engines, the following advantages are claimed: first, it occupies less width; second, being in a central position and connected directly with the piston and cranks, various cross strains are avoided and it is not so liable to breakage, the consequent probable damage being also greatly diminished; thirdly, the crosshead, crosstail, and various parts are entirely suppressed, and consequently all the parts of the engine are more accessible and more easily cleaned when in operation. In short, the engine is nearly balanced by means of two air-pumps, one on each side of the main centre, and is therefore less liable than marine engines generally to be brought up in a heavy sea. The steam-slides are so proportioned and adjusted as not to close the exhausting port till after the turn of the stroke, thereby obviating the danger of breakage by water in the cylinder, and suppressing the escape-valves. The expansive gear operates with precision, whatever be the speed of the engine, and supplies self-acting means of regulating the expansive working of the machine. The object of the inventor of this engine is to fit vessels of all kinds with engines of different constructions,

and with a classified gradation of sizes, whereby it is calculated that ten different sizes would meet all the requirements of steam-marine service in this country, which now employs upwards of 1000 different sizes and constructions.

In the Belgian division are two locomotive engines, one or two marine engines, and several paddle-wheels. The *Societé Cockerill* exhibit a marine engine of 150 horse power for paddle-wheels, but the principle, though good, has been superseded in this country. It consists of two oscillating cylinders working the same crank; and, whether we look to workmanship or material, it cannot compare very advantageously with those in the English departments. Similar remarks may be applied to the horizontal engine of Derosne and Coil in the French division. It is connected to an air-pump, used for the purpose of exhausting a boiler, in which the process of extracting sugar from beetroot is carried on. The paper-mill of Middleton and Elwell in the same department, is an English production, made principally by Englishmen, the firm having been long established, in one name or other, in Paris, and employing several of their own countrymen.

The improved railway carriage exhibited by the North Western Company is deserving of a passing remark or so. The principal object in view is to diminish the dead-weight of the vehicle itself, which has been hitherto in so disproportionate a ratio to the profitable weight of the passengers. The first class carriages, in present use, weigh from four to five tons when empty, so that scarcely more than eighteen passengers can be carried, with their accompanying luggage. In America, on the other hand, it is alleged that carriages are so constructed that they can transport as many as eighty passengers, with very little more dead weight than we have with our eighteen. The vehicle in question is so constructed as to have greater durability and safety, by introducing iron instead of wood into the framing and body; and the sheet-iron used for the panelling is corrugated, which not only increases the strength but gives greater beauty to the carriage. The carriage is supported by six wheels peculiarly constructed, each wheel being formed of wrought-iron in one solid piece, tire included, which gives greater security against fracture than though constructed in parts. The dimensions of the carriage is forty feet long by eight feet wide, and is divided into two first-class bodies, each capable of containing eight passengers, and sufficiently high for a person of ordinary stature to stand upright in them. There are five compartments, each of which accommodates twelve second-class passengers, besides compartments sufficiently large for

the luggage of the passengers and the accommodation of the guard. This carriage may be regarded, therefore, as a train in itself, capable of conveying seventy-six passengers, with their luggage and guard, —the total weight of the vehicle, without its load, being eight and a half tons. The same number conveyed upon the plan now in use requires a dead weight of from seventeen to eighteen tons.

This naturally leads us to the "detonating fog signals" of Mr. E. A. Cowper, which ought to be carefully examined, as they are in use on several lines of railway, and have been found efficient in all states of the atmosphere.

Let us now turn to machines of a humbler nature, though equally interesting, both in their structure and in their results. There are several Jacquard looms at work, either by power or by hand, and, as there are one or two improvements upon that beautiful invention, we shall give them the precedence. There is one machine (Messrs. Forster's) working by power which divides the cards by a simple contrivance, and which not only weaves the figure much easier, but materially facilitates the *mise en carte*, or the fixing the warp in the loom, the tedious, expensive, and preliminary stage of the process. In addition to this marked improvement upon the Jacquard, there is Mackenzie's patent reader, which enables an ordinary weaver to set up his own warp, a branch of the art hitherto confined to a certain class of workmen, and rarely attained by the many. The construction is simple but effective, and will materially shorten the preparatory labour of the weaver, if he have the chance of benefiting by its ingenious instruction. But on the heels of this short cut to knowledge in the weaving art, there appears in another quarter of the Exhibition an invention that will supersede, at one fell swoop, both the card-complication and the instructive reader of the Jacquard loom. In the Belgian department there stands a simple and unobtrusive machine, or rather loom, patented by M. Martin, which guarantees to weave the most complicated figure without the use of cards, and, judging from passing observation, we should say that he has accomplished his purpose. The loom is so constructed that it can stamp the simple substitute for the cards at the rate of 3000 per hour, and it requires no reader. This we consider one of the greatest inventions of the age.

There are three envelope machines in the Exhibition, two of them proclaiming abroad to the world, by their diurnal click-clack, their peculiar power and ingenuity; the third is silent and unobtrusive, although by no means the least ingenious and effective in its con-

struction. The machine of Messrs. De la Rue attracts the greatest attention, from its position and also from its beautiful construction: it can fold, allowing it to speak for itself, 60 envelopes per minute, or 3,600 per hour, with the greatest facility. That of Messrs. Waterlow works, we believe, with still greater velocity, and certainly throws off its work in a somewhat more attractive style. The machine of M. Remond, of Birmingham, is not at work; but, judging by appearance and the statement given of its efficiency, we should conclude that it is equally as effective as either of the two just mentioned. It is somewhat singular to observe the different constructions of the three machines, and by what means their respective inventors arrived at the same results.

M. Berthelot's "Circular Knitting Frame" is a useful and ingenious contribution; it obviates one or two important difficulties in that form of machine. For instance, the sinker wheel is omitted, and its place supplied by a circle or ring which regulates the motion of the sinkers. As soon as the thread enters the loop of the needles it is retained there by the sinkers, until the proper wheel has passed over it, when the mesh is pushed off on to the lower web. The mesh can only be formed regularly in this way. Cotton, flax, wool, silk, or even iron wire can be manufactured by this truly ingenious machine.

Another instance of machinery being so simplified in construction and power as to administer to the ordinary wants of society in the most economical form, is afforded in Cox's Patent Aerated Machine. By this invention pure soda, and other mineral waters, can be manufactured without the aid of force-pumps or other mechanical means of pressure, hitherto indispensable; and so simple and effective is the operation of the machine, that it can produce 596 gallons in ten hours of pure soda-water, or about eight times the quantity that the old process can produce, with the aid of steam-power and air-pumps. The construction of this useful machine is exceedingly simple, and may be described as follows:—There are three vessels of hammered copper, two of them tinned on the inside, and the other lined with sheet lead to resist the action of an acid. The two large or tin-lined vessels are the *generator* and the *purifier*; the smaller or lead-lined vessel attached to the generator is the *acid receiver*. Each of these vessels is constructed in two parts, and connected in the centre by means of flanches and bolts or screws. A regulated communication is preserved between all these vessels, so as to secure the required result. The operation of the apparatus is as follows:—

Suppose the gas-generator to be charged with about four gallons of water, and about two gallons of carbonate of soda, chalk, or other suitable alkali; the acid-receiver to contain about one gallon of sulphuric, hydro-chloric, or other suitable acid; and the purifier to be about half-filled with water, all the apertures being closed. Sufficient acid is then conveyed from the acid vessel to the generator, so as to disengage the carbonic acid gas in the contents of the latter; and the gas evolved during the neutralization of the acid by the alkali will force the atmospheric air completely out of the generator, by means of an escape tap, and occupy its place. The gas thus generated is passed by means of a pipe into the purifier, and after passing through the water contained in the latter it is then conveyed into the cylinder containing the liquid to be aerated. There is a gauge to indicate that the gas has attained the required pressure. and to regulate the charging of the vessels with the materials; and such is the power of the vessels properly charged and acting in unison with each other, that eighteen gallons of water in the cylinder can be charged with an excess of carbonic acid gas, at a pressure of from 300 to 400 lbs. per square inch, in the space of about twenty minutes, or even two cylinders of eighteen gallons each. This machine is simple, effective, and economic in its operation, and will prove a great desideratum in the production of all aerated beverages.

The "Improved Silk-Throwing Machine" of W. Frost is a useful invention; its advantages are obvious, when compared to the old machines. The winding-engine contains a greater number of "swifts" in the same space than could be admitted in the old plan, still leaving the "swift" the same breadth. The "standards" are half-length, and bracketed simply to contain the "swift," which is less liable to "knock," and the "bobbins" are turned by double wooden rollers, made of one solid piece of wood, which causes them to run truer than others. The rollers are covered with leather, which obviates the use of chalk or resin, the latter frequently soiling the silk. We have not space to enumerate the various improvements in this machine compared to the old, therefore we shall content ourselves by stating that it occupies comparatively little space, is both effective in its operation, and economical in its results.

The "hydro-extractor" of Manlove, Alliott, and Co., is a valuable contribution to the manufacturing art, and is ingeniously constructed. The articles are placed in a vertical cylinder, which rotates to any given velocity, and, as they are subjected to a strong current of air, generated by the rotation, they soon become quite dry and fit

for any subsequent operation. The goods are not injured by this process, as the only pressure or force to which they are subjected is that of the folds acting upon each other, by virtue of their centrifugal tendency; but even in the finest material this action does not occasion the slightest abrasion in the texture. Every adhesion of fibre after the ordinary mode of wringing is also obviated, and all creases prevented. Another advantage is, that the moisture is uniformly abstracted from the article by this process, and, as little heat is required, the injury frequently occasioned to the colours and the fabric is completely avoided. Again, when a determinate quantity of moisture, starch, or soap is requisite to be left in the article, that quantity can be fixed exactly by the machine's rotation, as it can perform either 200 or 2000 revolutions per minute. In the dyeing process, where a larger quantity of the material is required to be extracted, or in the finishing process, when fancy or fugitive colours are employed on heavy articles, it is equally effective; but in domestic affairs it might be most usefully applied, as it would obviate the destructive process of wringing the clothes after washing, which is frequently more injurious than the ordinary wear and tear. The machine will hold from 100 to 300 pounds of wet goods; and for hospitals, asylums, workhouses, and other large establishments where economy is more particularly practised, it must prove a great desideratum. It is used by almost all the large cotton-printers and cotton manufacturers requiring the aid which it so effectually renders.

Aimé Boura's "colour extractor" is another of those useful inventions which our manufacturers instantly avail themselves of in fabricating their articles. This simple machine can extract more colouring matter in two hours than the old system of boiling can in eight hours, and the colour is much brighter. The saving effected has been proved to be ten per cent. in all kinds of dye-wood; in cochineal, Prussian berries, and galls, fifteen per cent.; and in bark, twenty-five per cent. In all the first-class dyeing establishments this instrument is an indispensable requisite.

Mr. Taylor, of Nottingham, exhibits some beautiful specimens of his lithographic art; and of his engraving, ornamental printing, die-sinking, and embossing. Some of his printed papers represent ornamental woods inlaid with metals; others have all the beauty and delicacy of lace fabrics, upon coloured grounds, which are highly effective. There is also a machine for stamping lamp-shades in the same contribution, which is well worthy of a quiet and attentive observation or so. Jarrett's "embossing press" is a small and com-

pact piece of machinery, which does its work cleanly and effectively; and the pin-sticking apparatus of Peyton and Elis is another mechanical curiosity which deservedly attracts attention. This little machine has superseded the old method of sticking pins, as it preserves their brightness and prevents the points from receiving injury. J. P. Woodbury's "planing machine" is a useful contribution to structural purposes. It works most effectually, passing over knots and other peculiar obstructions by a device which is called a "yielding bar mouth-piece," which holds the grain of the timber together while being planed. Its capacity may be estimated by its planing boards twenty-four inches wide, at the rate of eighty to ninety feet in length, in a minute; and, also, by planing 6000 feet of board in one hour. Day and Millwood, of Birmingham, have contributed their peculiar excellence in weighing machines; their large beam, from its nicety of balance, attracts general attention.

Messrs. Cunningham and Carter's "new system of propelling carriages on railways" attracts a great deal of attention in the Exhibition, even from practical observers. It assumes to obviate a great many difficulties attendant upon the present system of locomotion. The "improved" carriages run upon lines of rails laid down as usual, but their propulsion is effected by rails attached to their sides, which derive their motive-force from being brought into contact with the peripheries of a succession of revolving, horizontal wheels, placed in sets of three each, at distances of about 300 feet apart—one wheel being placed outside of each line, and the third between the two lines—all these being connected and put in motion by air-engines, which communicate with an atmospheric main, common to all the engines, laid down outside the rails, beneath the surface of the ground. The shafts of the three horizontal wheels revolve in proper bearings, within an iron case, fixed in a trench beneath the rails, and extending transversely into the banks. The propelling wheels are above the ground. The advantages to be gained by this plan are manifold, according to the programme of the inventor; the main one to our mind is the following:—"Power being always in readiness, trains may follow each other in rapid succession, while their starting may be so regulated, independent of the drivers or guards, that it shall be impossible for one train to overtake, or to come into collision with, another."

M'Nicoll and Vernon's "steam travelling crane" is one of those marvellous acquisitions to simplify and abridge labour, which have enabled us to become so thoroughly practical as we are, in almost all

our pursuits. This crane can be worked either by steam or by hand; by the former, where it has scope for action, it must be amazingly effective. In our dockyards, and in all great undertakings of a structural nature, it will prove singularly efficient as an aid. It may be worked similar to Nasmyth's hammer, by a youth on a platform; and who, by moving two or three handles, enables it to lift weights varying from one to five tons, to load or unload carriages, to pile the materials, or to convey them from one space to another, a distance of 127 feet. The economical bearings of the invention are important. One of these cranes has already displaced two of the ordinary kind, the latter employing four men each—three men on the platform to hoist, and one man below to fasten on the logs—in all, eight men, at 16s. per week, each, or £332 16s. per annum. This crane is worked by a youth at 10s. per week, or £26 per annum, thus effecting a saving of £306 16s., and doing its work much more effectually.

Ryder's "drawing metal machine" is an effective invention, and simply constructed. The plan of elongating tubes or rods is ingenious, and the only surprise is that it has not been adopted long ago. A similarly-constructed machine is used for percussion caps, and for other purposes, at Birmingham, and is found to work to great advantage. Davis' "rotatory engine" appears a very compact and effective invention; its wear and tear and cost of material must be tested before any definite opinion can be given of its value; it has, certainly, one advantage—it occupies but very little space.

The lithographic machine of Messrs. Maclure, Macdonald, and Co. is a great improvement upon the one in ordinary use, as it not only simplifies the labour, but considerably increases its power. By this invention the principal labour is transferred to the steam-engine. The machine in ordinary use is worked by levers with eccentric points, and the carriage with the stone is carried under the scraper by means of a roller, but the work is frequently found untrue, as the machine becomes more or less used. The scraper, by the improvement, gives the necessary pressure as it passes over the stone, relieving itself when required, and also returning to the point of starting. The stone, likewise, is secured against breaking, which hitherto has been a great difficulty, and the work effected by the present machine is much more regular and perfect.

## CHAPTER XII.—AGRICULTURAL IMPLEMENTS.

The display of agricultural implements is more than ordinarily varied and interesting, there being several new contributors to this branch of mechanical adaptation, and almost all the old ones; the former endeavouring to acquire a reputation, while the latter appear to have exerted their greatest power, in order to sustain that which they have already acquired. The agricultural implement makers have long been accustomed to periodical exhibitions, therefore such an incident was no novelty to them; they had simply to go through a certain routine, which had become familiar through practice, to produce the best article in their power, and calmly await the judgment that must ultimately be passed upon their respective productions. They had an additional advantage, too, over other exhibitors, inasmuch as there was little to apprehend from foreign rivals: therefore they could measure beforehand pretty nearly the relative amount of competition which they would have to endure. We shall therefore content ourselves with briefly enumerating the leading contributions, and pointing out a few of the excellences which they singly present.

As the plough is the principal instrument in agricultural pursuits, it is natural that any improvement upon its construction should attract a great deal of attention. Ever since science began more immediately to direct its observation to the condition of agriculture, a series of improvements has been effected in almost every one of its relations, and all aiming at the same end—to facilitate labour, and thereby to augment its value. Farming now is gradually being brought to what it ought to have been some thirty or forty years ago—a manufacture of bread, of cattle, of sheep, and of corn, or, in other terms, a given amount of capital applied to land on the same principles that capital is applied to a manufactory, both requiring unremitting attention, unwearied industry, a thorough knowledge of the articles produced, and the markets where they can be disposed of, and, above all, the prompt adoption of each improvement, whether in machinery or otherwise, so as to augment the application of the labour-power and proportionately increase production. As the farmer is now deprived of his parliamentary night-cap, in which he slept and snored so comfortably, having no fear of the keen blasts of competition, the chances are that he will keep wide-awake to the preceding suggestions, and prove himself as shrewd a calculator as the cotton-factor or the mill-owner: if, on the contrary, the condition of his mind, from

long and inveterate habit, be incapable of such a metamorphose, he will find himself pushed aside, or perhaps crushed down by the Juggernaut of necessity, which has no compunctious feelings for its victims. There is little to apprehend, however, on this head, taking the great bulk of the agriculturists into account; so, at least, we presume to think.

Carefully observing the leading phenomena of the agricultural show, your eye is naturally attracted to the well-shaped and effective ploughs of J. and F. Howard, of Bedford. The agricultural society has fully appreciated the value of these ploughs by awarding their manufacturer so many prizes, and under so many trying and peculiar circumstances. We find in the journal of the Royal Society, in the report of a meeting held at Oxford as early as 1839, the following commendation:—"A plough by Messrs. Howard, of Bedford, of small size, with a mould-board of excellent form, calculated to give the least resistance in turning over the furrow, was much approved." After passing through a series of improvements, effected by its originator, and enduring a keen competition at all the agricultural shows, at most of which it gained the prize, we find the confirmation of its superiority in the report of the judges at the York meeting in 1848.

"The ploughs tried," say the judges, "were twenty-three in number, the trial took place on a clover ley, of excellent quality for testing the good and bad properties of the ploughs. The plan adopted was, for each to plough a land by himself, not less than five inches deep, and any width of furrow the exhibitors pleased. In consequence of the improvements which have taken place in these implements, and particularly in the furrow turner, it has become a difficult task for judges to come to a decision. With one or two exceptions the ploughs worked exceedingly well; but after very close inspection we decided that Messrs. Howard's plough (J. A.) was the best. We considered the furrow-turner pretty near perfection, and calculated to plough any description of land that a plough can do. We had no hesitation, therefore, even amongst this numerous and excellent class, in deciding in favour of this plough."

It is necessary to remark that this justly prized plough slightly varied from that which was commended at Oxford in 1839, although both are constructed upon the same principles, which we shall briefly describe.

The ploughs in the Exhibition of this manufacturer, are based more or less upon the same principles. The following is the type of them all. The patent iron plough is made principally of wrought

iron, and is constructed to be used either with four or with two horses,—its great merit, we believe, consists in its being the easiest draught for a pair of horses of any plough yet tested. The improvements consist in greater elegance of design, more equal proportions, and the cutting and moving parts—the share and furrow turner—being made strictly upon geometrical principles. The coulter is firmly secured by a simple adjustment, which prevents great loss of time, so much complained of in the old method of fastening it by wedges. There is also another improvement in this form of plough—the application of a draught chain, which removes all strains from the beam, and gives a steadiness of movement in hard work which cannot be obtained where the draught comes direct from the end of the beam. The line of draught is, also, much more direct, which necessarily diminishes the power exerted. Again, the hinder part of the draught chain may be removed, and attached to a hole in the centre of the beam, when ploughing stubbles, which are apt to drive up the coulter. The handles and beam are made in a single piece (of wrought iron), which prevents them from shaking loose, and obviates the accumulation of soil in the hinder part of the plough; in addition to which every part is so arranged that the ploughman can remove, or replace, the irons, in case of accident, without the assistance of a mechanic. This kind of plough can be worked with or without wheels, and is so constructed that a broad share for paring stubbles or turf, a share for subsoiling, and one of a triangular form to plough between the rows of beans or of root-crops, can be applied to it at will. The subsoil plough of this manufacturer has been equally approved of. Extending your view over the same contributions, you will find another invention equally available for agricultural purposes—the patent iron harrow. These harrows are ingeniously constructed, and their teeth so arranged that each one cuts a distinct track, but not parallel to each other, although the result is the same at the end of the ridge; the zig-zag form of the frame giving a diagonal direction to the teeth, which causes them to work cleaner and more effective, especially on wet and foul land. They are also made with projecting corners, which enables them to fall into the hollow parts of the land better than the old square implement. The draught is from the centre, which spreads itself equally over the whole surface of the harrows, and not, as formerly, liable to be frittered away, by one of the horses advancing before the rest of the team, and dragging the implement out of its regular track. In fine, for all effective purposes, this harrow has completely superseded the old implement, and has con-

siderably advanced the progress of agriculture within these last few years. The patent prize horse-rake is also another object of attraction at agricultural exhibitions, and is equally conspicuous in the Crystal Palace. The rake is constructed for raking hay, corn, stubble, or twitch grass. The draft-irons are furnished with a joint and quadrant, by which the teeth may readily be altered, so as to rake upon their points, or set more or less off the ground. This method is to prevent the rake collecting the soil and rubbish with the corn, an objection frequently raised against the use of horse-rakes. The bar running under the teeth, and by which they are raised, is so arranged that the teeth do not, as in other rakes, rest upon it, but are allowed to drop into any hollow parts of the land. The frame and teeth are made entirely of wrought iron, and the latter work independently of each other, so as to adapt themselves to the irregularity of the surface. It is worked on high wheels, which are capped, to prevent the hay, &c., working round the axles. By means of a simple pull-down lever, which requires only the strength of a boy to manage, the rake can be instantly emptied of its load without stopping the horse; in addition to which there are several other advantages to be derived from its use, arising from its peculiar mode of construction, and its adaptability to its designed purposes. The Messrs. Howard fully maintain their preceding reputation.

The next implement that particularly attracts attention is the Clod-Crushing Roller of Mr. Crosskill. This roller consists of cast-metal disks or roller-parts, placed loosely upon a round axle, so as to revolve independently of each other. The outer surface of each roller part is serrated, and has a series of sideway projecting teeth, which act perpendicularly in breaking clods. The size, six feet wide by two and a-half in diameter, consists of twenty-three roller-parts. Each alternate ring is made larger in the eye, and revolves undulatingly along the entire surface of the roller, whereby its power is increased, and the means of self-cleaning is preserved. In addition to the advantage of crushing clods, this implement is successfully applied to rolling corn upon light lands immediately after it is sown; and in the spring, after frost, it is found especially effective. It likewise imparts a firmness and tenacity to the surface of light soils, and obviates the tedious operations of the presser, which was formerly used. For rolling corn three or four inches out of the ground, when the land is infested with the wireworm and grub, it is equally useful and effective, having preserved many crops from utter destruction. Mr. Gibson of Newcastle has also a similar machine, but the prizes have generally been

awarded to the maker precedingly noticed. The "Patent Two-Horse Thrashing Machine" of Messrs. Barret, Exall, and Co., is deserving of more than a passing remark, its general utility fully entitling it to a more lengthened notice than we can afford to give. It is a great improvement upon those in ordinary use before its invention. The principal portion of the improvement consists in introducing a wrought-iron concave or breasting, formed of separate bars, with serrated faces, working through slots in the sides of the machine, and brought nearer to, or carried further from, the drum by means of two circles. These work round its centre with a continuous grooved worm cut on their faces by machinery, in which the endings of the breasting bars move. This arrangement allows the breasting bars to separate wider from each other, as well as more distant from the drum, which gives the larger corn (beans, peas, &c.) a wider space to escape through when thrashed. The machine is simple in its construction, easily worked, and is generally found to be most economical, where time and the preservation of the grain are duly considered. The "hand-thrashing machine" by the same inventor was once in vogue amongst agriculturists, and therefore equally entitled to notice. Now let us notice the "Broadshare and Subsoil Plough" of Mr. E. H. Bentall, which has proved so effective an instrument. This plough possesses the recommendation of being a broadshare, scarifier, and subsoil plough, combined in one and the same implement. It is therefore calculated to perform every kind of work that the old broadshare, skim, or surface plough could do; in addition to which it can effect the same results as a scarifier, a drag, and other instruments, used separately, besides being a subsoil pulverizer of great efficiency. The saving to the farmer who uses this compound implement must be considerable, as the economy of time, and the extent of work, when compared to the old processes, must be obvious, though good judges hold that compound implements seldom or never answer more than one useful purpose. Messrs. Clayton, Shuttleworth, and Co., appear exceedingly fortunate in constructing steam-engines for agricultural purposes. Their Seven-Horse Power Engine attracts considerable notice from its effective strength and general working capacity. The inventors have received several prizes for it at the agricultural shows, and there appears nothing to equal it in the present Exhibition. This engine is well adapted for counties where there is a great breadth of corn land, and may be made available for many purposes as well as for thrashing, such as sawing, pumping, or driving the whole of the barn implements upon a farm. They also

exhibit an "Improved Fixed Steam-Engine," having an oscillating cylinder, which greatly reduces the number of working parts, thereby less liable to get out of repair, better to be understood, and easier to be managed than the ordinary table or top-beam engine. Another advantage derived from these engines is that they occupy comparatively little space when compared with their power. Nor is the "Patent Portable Engine" of Messrs. Hornsby and Sons less entitled to a remark or two, if a general appreciation of its merits amongst agriculturists be of any account. This engine will thrash quite as much per day as six horses. It is so light in its structure that two horses can easily draw it on average good roads; it can also be applied to thrashing, grinding, sawing, chaff-cutting, and other analogous uses. The engine is mounted upon four strong carriage-wheels, with shafts, complete for travelling, and its important construction consists in having the cylinder and its connecting pipes placed inside the boiler or steam chamber, being thus effectually protected from the weather and frost at all times, besides diminishing the consumption of fuel. Another advantage is derived from this engine—namely, condensation, which so frequently proves injurious with cylinders outside the boiler, and occasions a great loss of time, cannot take place in them. The "Patent Thrashing and Shaking Machine" of the same firm is also an object of attraction. The presumed advantage of this machine is, that in addition to thrashing all kinds of grain, it combines a double crank straw-shaker upon a frame, moveable on four wheels upon which it stands to work, for separating the corn from the straw with a reciprocating trough beneath, which delivers all that drops through the shaker to a riddle placed on the end of the trough, where all the corn, chaff, short straws, &c., are separated. The "Portable Steaming Apparatus" of Messrs Richmond and Chandler is a compact piece of machinery, and has been worked effectually to its designed purpose. The apparatus requires no setting for steaming all kinds of roots, hay, corn, cut chaff, &c., used in the feeding of cattle; it is also provided with a self-acting motion to supply the boiler with water, and received the prize at the Shrewsbury Agricultural Show in 1845. There are few instruments applicable to agriculture that have so largely benefited the producer and rearer of live-stock as this apparatus, and it is deservedly prized by those who have availed themselves of its effective yet economic powers. Nor ought we to pass by the "Suffolk Corn Drill" of Messrs. Garrett and Son, whose working qualities have been so amply proved, and so severely tested. The system of drill husbandry is now almost generally adopted throughout the country, not only on

account of the great saving it effects in the quantity of seed and expensive manures, but also in the facility it affords for the use of the horse and hand-hoe, in cleaning and pulverizing the land between the plants. Many improvements, therefore, have been made in drills, which we shall briefly notice, all having one object in view—to economize the cultivation of the soil. There are drills for general, and drills for special purposes.

The "General Purpose" drill, as it is called, is adapted to deposit corn and seeds, either with or without manure, in any required quantities, and at any distance apart, each lever, in which the coulter is fixed, being moveable, to allow of its being set easily for the various kinds of crops. A great improvement has been effected upon the mode of drilling, by a simple alteration of the drill. Each conductor has now a separate coulter, so that the manure can be buried two or three inches deeper in the ground than the seed, and ten or twelve inches in advance of it, thus allowing time for the soil to cover the manure before the next coulter deposits the seed, and leaving any portion of mould between the two that may be required. The coulters being pressed into the ground by separate weights, as the levers are self-adjusting, no difficulty is found in depositing both seeds and manure regularly any depth, one below the other, and in all descriptions of land, however hilly or uneven. Another advantage is obtained from these drills—they can distribute the manure exactly where it is required; and such is their construction, that they can deposit from six to a hundred and fifty bushels per acre without stopping the implement, a great desideratum on hilly lands, where some portions are richer than others, and where the better soil has been washed off the hills into the valleys. A similar drill is exhibited by Messrs. Hornsby and Sons, although differing in construction; their relative excellence must be appreciated by agriculturists themselves, therefore we shall simply content ourselves with alluding to it. Messrs. Crosskill's single-horse cart is also an object of attraction, as it realizes what so long has been aimed at in the construction of such vehicles—increase of carrying power with lightness of draught. Here both are effectually attained. These carts, though comparatively small, are designed to carry 30 cwt. as an ordinary burden, which is too palpable an improvement upon the old lumbering, material-wasting, and useless structures, to need a moment's comment. Then there is Mr. Corne's straw and hay cutting machine, which effects an immense saving in labour, the first consideration in all industrial implements, and is deservedly appreciated by practical and enterprising agriculturists.

We must pass over a multitude of queer-looking machines, with just as queer names, and can only wonder how many of our honest, yet slow-moving, agricultural friends are enabled to appreciate them. But they must be appreciated, or there, it is fair to assume, they would not be ; nevertheless, we shall studiously eschew them, as they are beyond the range of our comprehension. And we shall serve the multitude of churns, racks, mangers, spades, forks, &c., &c., in the same way: go ye that want them, say we, and pick and choose, for there is choice in abundance, and fastidious indeed must they be who cannot please themselves. Machines are now getting so perfect in almost every direction of human labour, that but a small amount of bodily exertion seems necessary to satisfy our wants, as compared to the preceding condition of things; the only wonder is how we have managed to get on so decently as we have done without them, so essential, so indispensable, do most of them appear to a comfortable existence. We feed our horses and fatten our cattle with the aid of improved machinery, to the greater comfort, no doubt, of the poor beasts, and with greater economy to ourselves; for we are now-a-days literally killing them with kindness, which is true in more senses than one. Look at that iron crib for an ox to feed out of, and that "Archimedean Root-crusher," which prepares the food for the delicate creature; how comfortably he must spend his days, although they may be numbered a little more exactly than those of his lordly master. The god of the Egyptians never thrust his nose into so well-shapen an eating-vessel as that, highly-prized and dearly-cherished as he must have been; and as to saying that "the ox knoweth his master's crib," according to the old proverb, or something like it, we defy a country quadruped, fresh from the straw-yard or his native fields, to "smell out" the meaning of one of the newly-invented cribs, in the event of his master placing his food therein. Again, there is the "Patent Improved Pig Trough," and the "Circular Iron Pig Trough," both of which are ingeniously devised to teach the well-bred grunter to eat his food in a decent manner, and at the same time to economize the cost of his hide. Every thing, in fine, is intended to improve every thing that comes within the sphere of its operations.

In the American and Austrian departments there are several singularly-constructed agricultural implements, which may be effective in that country, under a somewhat normal condition of cultivation; but here, we apprehend, they would be found comparatively useless. If the "Churn," which, by the bye, is in the English department, although

an American invention, can turn milk into butter as easily as it pretends, it would prove a valuable acquisition to many of our dairies; and the root-crusher, also, might be made available in several of our occupations with great advantage. The reaping-machine, used with four horses, is a curiously-constructed implement, if we may be allowed the phrase: if it can accomplish the feats ascribed to its power by the inventors, such, for instance, as being able to reap from twenty to twenty-five acres per day, with the assistance of five binders, it must be deserving the attention of our agricultural machinists, and the more especially as Irish emigration is thinning the ranks of our corn-reaping labourers. No doubt it will be turned to account, as well as the mowing-machine, the knife of which is similar to that of the reaping-machine. We shall leave the other implements to more competent judges than we can even pretend to be.

Since the preceding remarks were in type, the prizes have been awarded to the agricultural exhibitors, and, with one or two exceptions, our opinions upon the relative merits of the implements have been fully confirmed. Every instrument that we have pointed out and described as a type of excellence has received a prize; but as there are several others whose merits we have overlooked, according to the judgment of the jurors, it is necessary that we should individually enumerate them.

### THE GREAT MEDALS.

Mr. Busby has obtained the great medal for his Two or Four Horse Plough, for his Horse-Hoe on the ridge, for his Ribbing Corn Drill, and for his Cart. The Plough which has been thus honoured is peculiarly adapted for certain descriptions of soils, having a moveable nose-piece, upon which the shares are placed, and which can be set more or less to the land, especially as regards the pitch. According to the exhibitor of the Plough, this is found to be a great advantage where cast-iron shares are worked; for as the latter wear down, the improvement in question enables the plough to retain its hold upon, or inclination towards, the soil. The Cart is equally deserving of notice. The body is made of planks, upon the simplest and most durable plan, and is laid sufficiently low on the axle to be tipped up with ease. The shafts are placed on the sides of the body, which not only gives greater strength to the vehicle, but also retains the proper line of draught. The naves of the wheels are made of wood and not iron, which render them more durable, and not so difficult to be repaired. The Society's Journal says, that it is

"suited for all purposes: easy for the horse, as the wheels are rightly made; easy for the labourer, as they are much lower than other carts; and wonderfully cheap." The Horse-Hoe has received several prizes. The construction of this useful implement is somewhat simple, having a triangular sock in the centre and two bent knives behind, followed by two sets of rowels, on the principle of the Norwegian Harrow. The latter clear the soil of the weed-roots, and leave them to rot on the surface, besides steadying the motion of the Hoe. The Ribbing Drill has proved itself of equal utility, and has been justly awarded a prize.

The Messrs. Garrett & Son have obtained the great medal for their Seed and Manure Drill, whose excellence we have already pointed out; also for their Steam-Engine, their Thrashing-Machine, their Horse-Hoe, their General Purpose Drill, and their Seed-Sowing Engine. Six first-class prizes awarded to one exhibitor would seem to indicate a more than ordinary amount of individual excellence.

Mr. W. Crosskill has obtained the great medal for his Norwegian Harrow, his Meal-Mill, his Cart, and his Clod-Crusher. The two latter we have already noticed in our preceding remarks; the Harrow has its peculiar excellence for certain soils, which seems to be justly acknowledged by the jurors.

Messrs. Hornsby & Son have obtained the great medal for their Corn and Seed Drill, Drop Drill, Two-row Turnip Drill on the ridge, Oil-cake Bruiser, and Steam-Engine. The Engine we have already described; the other implements are improvements in detail as compared to others of similar construction, which have been duly appreciated.

### MEDALS.

Messrs. Burgess & Key's Turnip Cutter has received a medal. This implement is so constructed that, with the aid of a boy, it can cut three bushels of turnips in one minute, either into one, two, or three sizes, and can discharge each size separately. It is equally effective in cutting chicory, mangold wurzel, carrots, &c. &c., and for all cattle-feeders it must prove highly useful.

Messrs. Clayton & Shuttleworth's Steam-Engine we have already described.

Mr. H. Clayton's Tile Machine appears like an effective invention, and has been rewarded accordingly with a medal.

Anthony's Double-Acting American Churn has attracted a great deal of attention. The construction of the churn is very simple; it can produce butter from the cream in twelve minutes, and not only better in quality, but more in quantity than the ordinary churn. By

a simple contrivance, the particles of air are quickly separated from the cream, without the slightest froth being generated on the latter, which is the great desideratum in butter-making. A medal has been justly awarded for this useful invention.

Mr. William Crowley's Newport Cart has also received a prize. It is a compact one-horse vehicle, combining strength, lightness, and durability; and, judging by its appearance, it must be easy of draught. The tipping-apparatus in front is peculiarly effective.

Mr. W. Williams has gained a medal for his Light and Heavy Harrows, which are good working implements of the kind.

Mr. W. P. Stanley's Linseed and Barley Crusher is a beautifully constructed and effective machine. It has gained what it deserved—the medal.

Mr. B. Samuelson's Turnip Crusher has also justly obtained its reward in a prize.

Mr. C. Burrell's Gorse Bruiser has been properly appreciated; and although his Circular-Saw Bench did not get a prize, it is equally deserving of attention from its effective working powers, as by its aid two men can complete a hurdle in a quarter of an hour.

Messrs. Smith & Co. have received three prizes: one for their Haymaker, a singularly constructed machine, but highly useful in its operations; another for their Chaff-Cutter, which is well known; and a third for their Horse-Rake, which has one or two improvements upon that kind of implement.

Messrs. J. and F. Howard have received an equal award to the preceding firm. Their Two-Horse XX Plough, their Four-Horse XXX Plough, and their well-known Horse-Rake, have been respectively adjudged a prize. In a preceding page we have described these useful implements.

Messrs. Holmes & Son's Threshing Machine has also received the award of a medal.

Messrs. Hensman & Son have been awarded three prizes: one for their Four-Horse Plough; another for their Thrashing Machine; and a third for their Corn Drill.

Mr. C. H. Bentall's Cultivator, one of the most useful and originally constructed implements in the Exhibition, justly gained the medal. It is described in a preceding page.

Mr. W. Ball's Two-Horse Plough appears to have been similarly appreciated.

Mr. R. Coleman's Cultivator and Expanding Harrow were equally pronounced entitled to the award of a medal.

Mr. Corne's Chaff-Cutter almost invariably obtains a prize; its usefulness is unexceptionable.

Mr. J. Comin's Horse-Hoe had to sustain a rather severe competition; nevertheless it stood its ground, and carried off a prize.

Mr. M. Gibson's Clod-Crusher we have already alluded to, and with Crosskill's implement to compete with, it must be pronounced a highly creditable production.

The Cart of Messrs. Gray & Son; the Meal-Mill of Mr. Harewood; the Top-Dressing Machine of Mr. D. Newington; the Oil-Cake Bruiser of Mr. W. N. Nicholson; the Drop Drill of Messrs. Ransome & May; and the Liquid Manure Distributor of Messrs. Reeves & Bratton, were respectively awarded a medal. The Tile Machines of Messrs. Whitehead and T. Scragg were equally honoured, and deservedly so. A prize was awarded to M. De Claes, a Belgian, for a Corn Drill and a Roller; and a similar compliment was paid to M. Odeurs, of Merlinne, for a Plough. M. Lavoisy, of Paris, received a medal for a Churn; so also did M. Duchêne, a Belgian, for a similar invention. Nor ought the Churn of Mr. Wilkinson, which also received a prize, to go unnoticed, as its working qualities were instantly recognized. The Steam-Engine of Messrs. Taxford & Son was equally prized, and justly obtained a medal.

Messrs. Barrett, Exall, and Co. have received a medal for their "Steam Engine," their "Thrashing Machine," whose excellence we have already pointed out, and their "Linseed and Corn Crusher." Mons. P. De Stampe, of Brabant, has also received a medal for his plough, which is highly creditable to his inventive powers; and a similar observation may be applied to the plough of M. Jenkin, of Utrecht, and to that of Messrs. Proutz and Mears, of Boston, United States. The French plough of Messrs. Talbot Brothers, of Bourges, is equally entitled to notice; so also is the "Seed and Corn Separator of M. Vichon, of Lyons. The "Draining Plough" of J. Fowler, of Bristol, was considered as entitled to "honourable mention."

## CHAPTER XIII.—GLASS.

The manufacture of glass is naturally of great interest to the inquiring reader, not only for the beauty of the material produced, but also for the variety of modifications which the ingredients are

subjected to, and for the manual dexterity shown in the processes. "Who," says Dr. Johnson, "when he first saw the sand or ashes by a casual intenseness of heat melted into a metalline form, rugged with excrescences and clouded with impurities, would have imagined that in this shapeless lump lay concealed so many conveniences of life as would, in time, constitute a great part of the happiness of the world? Yet by some such fortuitous liquefaction was mankind taught to procure a body at once in a high degree solid and transparent; which might admit the light of the sun, and exclude the violence of the wind; which might extend the sight of the philosopher to new ranges of existence, and charm him at one time with the unbounded extent of material creation, and at another with the endless subordination of animal life; and, what is of yet more importance, might supply the decays of nature, and succour old age with subsidiary sight. Thus was the first artificer in glass employed, though without his knowledge or expectation. He was facilitating and prolonging the enjoyment of light, enlarging the avenues of science, and conferring the highest and most lasting pleasures: he was enabling the student to contemplate nature, and the beauty to behold herself."

Since the alteration in the tariff, the manufacture of glass in this country has received an immense extension, and in several branches of the art we have outstripped the foreigner, who a few years since maintained against us a flourishing competition. In the preparation of the raw material, with one or two exceptions, we occupy the highest place, and have acquired this advantage by our large capital, by our improved chemical knowledge, and by the indomitable energy of our character. Even the foreigner acknowledges our superiority in these respects, and in taste and colouring he also admits that we have made considerable progress.

"For a long time," says M. Stephane Flachat, "England has excelled us in the manufacture of glass, especially crystal glass. The precise cause is not known; it does not appear in the mode of fusing the materials—more probably it may be attributed to the purity of the lead which they use. We know how poor France is in this important respect, having imported, for several years past, from fifteen to sixteen millions of kilogrammes of that metal, principally from Spain. . . . . . . The French glass is inferior to the English in point of colour, and changes much sooner when exposed to the air. Our manufacturers declare that this difference does not arise from an inferiority of workmanship, but from the limited means which we possess of purchasing the article, and which in a great

measure may be attributed to the *minute division of the soil.* In order to reduce the price of glass to the condition of the purchaser, our manufacturers have recourse to an extra infusion of alkali, which, being slowly absorbed by the atmosphere, causes the glass to lose its transparency."

Glass may be regarded, generally speaking, as an admixture of three kinds of ingredients—silica, alkali, and a metallic oxide. The silica is the vitrifiable ingredient, the alkali is the flux, and the metallic oxide, besides acting as a flux, imparts certain qualities by which one kind of glass is distinguishable from another. If silica be exposed to the strongest heat it will resist fusion, but if it be mixed with an alkali, such as potash or soda, and the mixture be then submitted to the same temperature, a combination will ensue which takes the form of a liquid, and when cooled becomes transparent. The quality of glass mainly depends on the proportions in which the silicious matter and the alkali are combined, on the temperature to which they are exposed, and on the skill with which the entire process is performed. When a perfect combination of the materials is not secured, the glass is covered with dark spots or particles, and other inequalities, which are called striæ. There are three kinds of glass in ordinary use—crown glass, plate glass, and flint glass. The silicious sand, which forms the base of the manufacture of each, is principally derived from Alum Bay, in the Isle of Wight; from Lynn, in Norfolk; and from Aylesbury, in Buckinghamshire. The materials for flint glass are nearly as follows:—One part of alkali, two parts of oxide of lead, three of sea-sand, and a small portion of the oxides of manganese and arsenic. The oxide of lead is employed as a powerful flux; it also imparts a great lustre to the metal, and causes it to be more ductile when in a semi-fluid state. The manganese renders the glass perfectly colourless. When these ingredients are mixed, it is called the *batch*, and the mixture is generally of a salmon-coloured hue, the red tinge being given by the oxide of lead.

Among the contributions of Messrs. Pellatt to the Exhibition, there are models of the crucibles used in melting the glass. The crucibles are made of Stourbridge clay, which consists of a mixture of silica and alumina, in the proportion of nearly two to one. The manufacture, drying, and baking of the crucible, is an important process, since one pot, when filled, contains about 1600 weight of glass, the proper melting of which is essential to the subsequent labours of the glass-worker. These crucibles, or pots, are not moulded, but built up piece-meal, each piece being rolled into a cylindrical

form, and laid in a curve on preceding rolls; and so closely are they pressed together, to exclude the air between the rolls, that they form, as it were, a thick wall or crust. The weight of clay required for one pot is nearly one thousand pounds; and the dimensions of the finished vessel are about three feet in height, two and three quarters in diameter, and about three inches thick. The shape is nearly cylindrical, with a round top and flat base, and there is only one opening, about ten inches in diameter, at the upper part of one side.

Specimens of the glass in its several stages of manufacture are likewise shown. After the first ten or twelve hours, it appears like a honeycombed mass, white and opaque. The next stage it becomes transparent, but is full of air-bubbles; while the oxygen, supplied by the manganese, produces a light purple tint which supersedes the white colour. As the melting proceeds the purple tint gradually disappears, the air-bubbles are disengaged, and the glass is rendered homogeneous and fit for manipulation. The same party exhibits the various tools used in the process of manufacturing glass—the blowing iron, the workman's chair, the procellos, the punty, the shears, the battledore, and the pincers.

Flint glass ware, such as drinking-glasses, decanters, lustres, lamp-shades, and phials, are made by blowing and manual working; and, in a minor degree, by casting in a mould. As an instance of the *modus operandi* of glass-making, let us take the decanter. A man takes a hollow iron tube, about five feet long and half an inch in diameter, and dipping one end into the pot, collects a small quantity of the metal on its end. The metal appears like a lump of red-hot iron, and, from its consistence, is just able to be retained on the tube. The workman whirls it twice or thrice round his head to lengthen the mass, then rolls it on a flat iron surface to give it a regular shape, afterwards blowing through the tube to make the glass hollow. After repeating these processes twice or thrice, another workman receives the metal, and sits down in a chair having two flat parallel arms sloping downwards. Then, resting the tube on these arms, he rolls it backwards and forwards to keep the glass from bending; and a boy, stooping down at the other end, blows through the tube, which keeps the glass hollow. By the aid of an elastic instrument, shaped like sugar-tongs, the workman brings the mass into form, rolling the tube continually, and heating the glass frequently, so as to preserve the proper consistence. The "footer" then brings a little melted glass on the end of his rod, and applies it to the blown mass, to which it instantly adheres. This is shaped into a foot, and the whole is trans-

ferred from the tube to a rod called the "punty," the latter adhering to the foot of the decanter by a little melted glass, and the tube being detached by a touch with a piece of cold iron at its junction with the glass. Then commences the upper part of the decanter. The workman cuts off a piece of glowing glass with a pair of scissors, so as to allow of a depression for the lip, and the edge is bent and curved for that purpose almost instantaneously. The internal cavity and external surface of the decanter are gradually formed by the workman inserting the tongs into its mouth, and twisting it about as he pleases. The handle is formed by an attendant bringing a small mass of melted glass upon the end of his rod, which soon adheres to the vessel, and by a little dexterity of hand is fashioned to its proper form. These processes are performed with great rapidity, as the glass, being neither solid nor liquid, would drop from the tube if not kept rotating; on the other hand, it is capable, in this condition, of being pulled, twisted, stretched, cut, and pressed in almost every variety of form. The whole is effected by the manual dexterity and accurate eye of the workman, aided by a few of the most simple tools. Now follow the decanter to the "annealing" process, the object being to render the glass less brittle, and less liable to fracture from sudden alterations of temperature. If glass were allowed to cool at once in the open air, the external surface would contract more rapidly than the interior, whereby the glass would be in an unequable state of elasticity, and therefore liable to fracture. The slow cooling takes place in an annealing-oven, called a "leer," which has a long flat arch sixty feet long, five feet wide, and from one to two feet in height. Close to the door of the oven, on each side, is a furnace which keeps up a high temperature; but as there is no other heating power, the oven becomes less and less hot as the distance from the mouth increases, until, at the extremity, it is scarcely warmer than the surrounding atmosphere. Along the floor of the oven are tram-lines, upon which the iron trays, called "leer-pans," travel with the glass to be annealed. The time for annealing depends upon the thickness of the vessels, varying from twelve to sixty hours. The next process is cutting the decanter. Suppose yourself in a room with several workmen, each of whom has a thin wheel, revolving on a horizontal axis, before him; and above some of the wheels are vessels containing a mixture of sand and water, which drops on the edge of the wheel. These wheels are of various sizes, and made of various materials, such as cast-iron, wrought-iron, Derby-stone, and willow-wood, and they are all worked by power, the workman having the means of changing

his wheel at will. The edge of the wheel effects the grinding, therefore different thicknesses and shapes are given to it, in order to produce the required results. The decanter is now in the workman's hand, who holds it against the edge of the revolving wheel, which grinds down the substance, and produces either a flat or curved surface, according to the pattern desired. All depends upon the accuracy of his eye, and the dexterity of his hand, in producing the proper form. The iron wheel, with sand and water, is used for grinding away the substance of the glass; the stone wheel, with clean water, for smoothing the surface, and the wooden wheel, with rotten-stone and putty-powder for polishing it. This is simply glass-cutting. The more costly articles are engraved, that is, devices are cut on the surface more delicate than can be produced by the cutting-wheel. Suppose the engraver, with decanter in hand, seated before a small lathe, with several copper wheels at hand, and varying from an eighth of an inch to two inches in diameter. He attaches one of these to his lathe, touches the edge with a little emery moistened in oil, and then holds the decanter against the disk, or wheel, by which very minute indentations are produced. By dexterity of hand he can so combine the indentations that a beautiful intaglio, or sunken picture, is produced. This process requires the most expert and superior class of workmen.

Here we may remark that each firm adopts its own peculiar views as to the choice and proportion of the ingredients employed in composing what is called the *batch*. This is especially observable in the manufacture of glass, as it involves such a singular chemical union of heterogeneous materials, that it may be deemed an experimental art, the experience derived from past trials being made the ground for future ones. It may not, therefore, be uninteresting to describe the varied processes in use on the continent, which we acquired during our "walks through the workshops" of Europe, and which may become not only suggestive of new ideas in the art of glass-making to the practical reader, but also amusing and instructive to those who have no such object in view. The general process of mixing the *batch* in Bohemia, which likewise obtains in France and Belgium, is as follows ;—One hundred pounds of sand, 60 of red lead, 30 of purified potash, 2 of nitre, and 4 of manganese. Sometimes thus :—4½ cwt. of sand, 3 cwt. of red lead, 168 lbs. of pearl ash, 50 lbs. of saltpetre, 1½ lbs. borax, 1 lb. of arsenic, and 2½ oz. of manganese. For very fine flint: —120 lbs. sand, 40 purified pearlash, 35 lbs. litharge or minium, 13 lbs. nitre, and from 2 to 4 oz. of manganese. When manganese is used

as a colouring matter arsenic must be omitted, as the arsenite salts of the latter destroy colour.

*Crown Glass*—is that with which windows are generally glazed, and which is also used for framed prints and drawings. It is always made in a circular form, rather thicker at the edge than elsewhere, having a knot or bulb in the centre, though the glass is always used in a quadrangular form, which occasions a certain loss on its being cut up for use. The ingredients for crown glass usually comprise the following:—Clean white sand, soda or potash, and lime, the first two constituting the glass, while the lime acts as a flux to enable the others to combine more readily.

Suppose the "frit," or the prepared materials, placed in the melting pots, together with a portion of "cullet," or broken glass, and both together exposed to an intense heat, whereby they are melted into a liquid glass. The impurities rise to the surface, and are then skimmed off by an instrument. The glass, or "metal," is not in a workable state when quite liquid, but by slackening the heat a little, it becomes slightly coagulated, and is in that state fitted to undergo the operations which constitute crown glass making.

Each "table," or circular piece of glass, requires only a few minutes in making, but the services of twelve men are requisite to complete it. The first man, the "gatherer," dips his iron tube into the molten liquid, then turns it gently round until he has acumulated a pound or two on the end; this is allowed to cool a little, when the tube is again dipped into the liquid, which increases in quantity, and so on until he has gathered about nine or ten pounds of the glass on the end of the tube, turning the latter constantly to prevent the metal falling off. He holds this mass perpendicularly downwards, to stretch it somewhat beyond the end of the tube, and then rolls it to and fro on a smooth iron plate, called a *marver*, to give a cylindrical shape to it. His assistant then blows through the tube, which makes the glass hollow within, and causes it to assume the form of a pear. It is then handed to another man called the blower, who heats it at the furnace two or three times, and after each heating blows it and turns it round, until he enlarges it to the size of a globe. The side opposite to the tube is then slightly flattened, by being pressed against an iron plate, and the glass is tranferred quickly to an iron rod, or "pontil," by the blower holding the tube horizontally, while another man collects a little melted glass on the former and applies it exactly opposite the tube, which is immediately detached by touching the point of junction with a piece of iron dipped in cold water. This

globe is next changed into a flat circular sheet. The workman holds the pontil so that the glass shall be exposed to the heat of a furnace, at one of the mouths called "nose-holes." He rests the rod at one particular point on a bar, which may be called a fulcrum, and keeps the glass rotating while exposed to the heat. As the glass becomes hotter and softer it yields more readily to the centrifugal force caused by the rotation, until it becomes broader and broader, and deviates more and more from the shape of a globe. The hole formed by the tube, which at first was only about two inches in diameter, gradually increases until it becomes so large, by the whirling action, that the flattened globe assumes a circular and sheet-like form, about four or five feet in diameter, nearly equable in thickness, and still attached to the rod exactly at the centre. This is always regarded by the uninitiated as one of the most beautiful and interesting operations in the manufacture of glass. The mode of detaching the rod from the glass is equally attractive. The rod is rotated for a few times after the glass has "flushed," as the last operation is called, at such a distance from the fire as to give it sufficient coolness to maintain its shape. The man then carries it a short distance, and places it horizontally on a bed of sand, when the rod is instantly detached by another man. The circular piece (having the "knot" in the centre) is then lifted up on a wide two-pronged fork, and placed upright in an annealing oven, where it cools gradually, and loses the brittleness it would otherwise have.

The Messrs. Chance and Co., at whose large establishment * we observed the preceding operations, exhibit several specimens of crown glass in their contribution. And of sheet glass they have a still greater variety, as it enters, we apprehend, more largely into general consumption. The specimens of the latter are five in number, comprising the different thicknesses to which they are blown, and weighing respectively 13, 16, 21, 26, and 32 ounces per square foot. The process of making sheet glass is somewhat simpler than the preceding, but equally

* At Spon Lane, near Birmingham. This firm have erected schools and accessory buildings at a cost of more than £5000, where upwards of four hundred children, boys and girls, varying from two to seven years of age, are taken care of during the day and educated. The parents have only to pay 3d. per week for each child, the expenses of the establishment, such as books, paper, and tutors, being provided by the beneficent founders. The works form a complete town within themselves, comprising upwards of sixteen hundred hands, with medical attendants, the latter being supplied gratuitously. And this vast fabric is the result of a comparatively few years' labour; such, however, is the industry of man when directed by the agency of the best attributes of his mind!

amusing and instructive. A quantity of the molten liquid is gathered on the end of an iron tube, and blown into a spherical form by the workman ; it is then heated in the furnace, and the fluid mass is swung round by the latter, who stands on the edge of a pit, until it becomes elongated to the required extent. The cylinder thus formed is then cut off at both ends and down the middle, after which it is placed on a flattening furnace, when it gradually spreads out to the form of a sheet, and only requires annealing to become a perfect pane. The Crystal Palace is glazed with sheet, not crown, glass, weighing sixteen ounces per square foot, and each of the panes is forty-nine inches in length.

*Plate Glass*—or, to use a more appropriate term, *cast glass*, is founded in a liquid state, and is totally different from blown glass. Suppose a large table, upon which is a casting apparatus in the shape of a carefully prepared plate of iron, with various mechanism to place it in any desired position. This iron plate determines the size of the sheet of glass. The ingredients used as a basis are sand, alkali, and lime, but there are several others which are carefully concealed, although minutely mixed and proportioned, besides those already named. The ingredients being "fritted" and mixed with "cullet," or broken plate glass, are melted in the furnace to a red heat, and to a liquid state ; and when the "lava" has arrived at a particular state it undergoes an examination, which requires great care. Three men take a copper ladle, having a long handle, dip the ladle into the molten glass, and convey it to a small flat slab or tray, on which it is poured out. One man holds the handle, while the other two support the bowl of the ladle by cross handles. The red-hot mass is so soon affected by the coolness of the atmosphere, that it assumes a coagulated consistence when placed on the tray. A man then examines it, to see whether any slight difference of colour indicates defective spots, knowing from experience what are the causes of these spots, and in what way they will affect the purity of the glass when finished, he therefore removes them with the pointed end of a rod, which leaves the mass in a homogeneous state. The mass is returned to the ladle, and the three men carry it back to the furnace. It is now put into different pots from those which before contained it, so that the same pots become filled with the successively examined portions. When the quantity is sufficient for one casting—comprising several hundreds weight—the pots are exposed to a heat sufficient to bring the metal to a liquid state. About thirty or forty hours are required for melting and combining the materials to a proper condition, which is not

exactly a liquid state; but after the perfect melting has taken place the mass is allowed to cool a little, so as to acquire a slight degree of viscidity. At the proper time the *cuvette*, or vessel containing the molten metal, is drawn out of the furnace by means of a crane, and quickly conveyed to the casting-table; then, at a given signal, its contents are poured in a stream upon the table beneath, and a heavy polished iron roller passed over its whole surface. This roller rests on two grooves equal in height to the intended thickness of the plate of glass, so as to spread out the ductile mass into an equable sheet over the table. As soon as the plate has become solid, the door of the annealing oven is opened, when it is dextrously thrust in, and the door closes tightly, where it is allowed to cool gradually.

As these plates leave the casting-table they are rough and uneven on the surface, and have to undergo the process of polishing, which is somewhat tedious and lengthened. The most simple process is that adopted by the Messrs. Chance, and which has proved so effective in its application. Imagine a smooth slab of the size of an ordinary sheet of glass, and above it a number of felted polishing rubbers, the slab below moving at a slower rate, and transversely to the rubbers above, and so regulated that the sheet of glass between them should receive a uniform polish or surface; then further imagine some hundreds of these slabs in a series of large rooms, kept in constant action by the aid of powerful machinery, and covered over with red oxide of iron, the material in common use for polishing, and you will have a faint idea of the effective nature of the process. For a glass of large dimensions, of course, a different process must be adopted, the principle being nearly the same.

"One of the most important points,"* says M. Flachat, "in the manufacture of glass is the polishing. In England they are more advanced than we are in the operation, it being effected by superior mechanical means. French glass, it is true, is of a whiter tint, but the English has less defects; the first arises from using wood in our furnaces, whereas the English use coal."

The *silvering* of glass, in which we are somewhat behind the French and Belgians, although greatly in advance of them in every other respect, is effected in the following manner:—A sheet of tin-foil is laid on a flat stone or slate table, and on this is poured some mercury or quicksilver, whence probably the term silvering. The plate of glass, being first made perfectly clean, is placed on the liquid mercury in such a way as to expel all air bubbles from between the

* Vide Rapport de 1844.

two; then heavy weights are placed on the glass to force out the surplus mercury from beneath. The whole is allowed to remain in a slightly-inclined position for some days, after which it is found, on removing the weights, that the mercury has combined with the tin-foil, and that both together have adhered to the glass, forming what is commonly called the "silvered" surface, which causes the reflective powers of the mirror glass.

The method of transfixing patterns upon glass, which we saw practised to a considerable extent at Spon Lane, as though it were ground, is exceedingly simple, yet highly effective. A paste, composed of fine ground glass and gum-water, is brushed over the glass until the surface is perfectly smooth and uniform; then a strip of thin metal, cut into a pattern, is passed consecutively over the sheet, after being rubbed with a toothbrush over the interstices left by the pattern, which removes the paste to the precise form required. It is simply the reverse way of painting letters, by means of a cut strip of metal, upon a sheet of paper; in the latter instance the black is impressed upon the material, whereas in the former the paste is removed from the surface of the glass. When this process is gone through the glass is submitted to a certain degree of heat, and the pattern becomes ineffacable. The form of the pattern is effected through the agency of nitric acid and grease, so that there is no engraving required.

The *flashing* the glass is also interesting. It consists in giving an object a coloured coating, which, combined with subsequent cutting, produces several of the various and beautiful effects observed in the ornamental articles exhibited. Nothing can be more simple than the process by which these effects are produced. The object being formed first in white transparent and colourless glass, and this being allowed to slightly cool, it is dipped in a pot of coloured metal in a state of fusion, and, being suddenly withdrawn, it carries away upon it a thin coating of coloured glass, which immediately hardens, and becomes encrusted upon, or rather incorporated with, it. The article is then shaped by the processes of the glass-maker, and if it be afterwards cut, those parts which are cut will disclose the transparent glass, the parts not cut remaining coated with the colour. It is evident that an infinite variety of figures may thus be formed, the outlines of which will be defined by the coloured and clear glass.

One of the most beautiful and interesting departments of the art of glass-making, however, consists in imparting to glass a variety of transparent colours. This is effected by adding to the usual ingredients of glass the oxides of certain metals, which have the power of

imparting to the structure of the glass a quality by virtue of which it absorbs certain constituents of the solar light, and reflects others.

In the highly intelligent volume of Mr. Pellatt,* we learn, according to his practical mode of mixing the metals, which he has also illustrated in his contributions to the Exhibition, that it has been hitherto generally supposed that the oxides of particular metals had the exclusive virtue of producing certain colours upon the glass. Thus cobalt was supposed to have the exclusive property of producing blue and copper green; but it has been very recently shown that any of the colours may be produced by any of the ordinary metals, the colour varying according to the degree of heat to which the mixture, or the colouring metal, is subjected. Iron, copper, cobalt, manganese, gold, and uranium are the metals chiefly used in imparting colour to glass. The different specimens of Messrs. Pellatt will clearly illustrate our meaning. The green shades of No. 18 are produced by the oxides of iron and copper combined in different proportions, the yellow tints being due to the iron, the blue to the copper, and the green to their combinations. No. 19 is a dim yellow, produced by the carburet of iron. No. 20 is a blue, produced by the oxide of cobalt. No. 21 is a purple, the production of the oxide of manganese. No. 22 are the shades of rose and ruby produced by the oxide of gold. No. 23, a fine specimen of the topaz, is produced by the oxide of uranium; and No. 24, a fine emerald, is the result of copper and uranium combined.

And Mr. Pellatt justly remarks that, "it would be matter worthy of scientific investigation as to how far the oxides used in giving colour to the 'metal' are effected by the various qualities of fuel. Our flint glass is unrivalled as regards colourless purity of substance. No Continental specimens can, for a moment, stand comparison with the productions of Birmingham and Stourbridge." The use of lead in our flint glass, while it imparts lustre and ductility to the metal, has a tendency to diminish the depth and brilliancy of colour which otherwise could be obtained from the oxides. Our glass is too transparent to receive the rich deep colour which the Bohemians have so long imparted to theirs; and the use of coal instead of wood is deserving of enquiry, as to its effect upon the colouring properties of the oxides. Nevertheless, we fully equal the foreign glass manufacture in almost all these respects; the shade of ruby forming, we believe, the only exception. It may be not only interesting, but highly useful, to append the method of colouring glass, which is in general use throughout Bohemia.

* "Curiosities of Glass-making."

*Blue.*—The oxide of cobalt imparts to glass a fine deep blue, which will stand the test of heat, and is produced by any flux. Cobalt is also used for the fine blacks, mixed with manganese and iron ; and with the yellow oxide of antimony it makes a fine green.

*Purple.*—The regular batch is three lbs. of manganese, and four oz. zaffre to every 100 lbs.

*Copper Ruby.*—Copper oxidated and calcined by heat, not excluding the air, will produce a carmine colour, or, mixed with iron, a full deep red. When contained in glass, add a quantity of tartar, at the moment of fusion, but it must be worked off immediately, as a long continuance of heat causes it to turn the metal, or mixture, green.

*Gold Red.*—One lb. flint glass, powdered fine, three drs. of iron scales, three drs. of yellow orpiment, three drs. vermillion, and three drs. of gold dust.

*German Copper Red.*—Seventy-one parts of sand, fourteen of oxide of lead, seven and a half oxide of copper, one of oxide of iron, two and a half fine clay, and one and a half lime.

*Black.*—In the regular batch put eight lbs. of manganese to every 100 lbs., and for deep black use a little oxide of copper.

*Green.*—520 lbs. of sand, 360 red lead, 160 pearl ash, thirty-five nitre, one soda, six and a half manganese, and three iron filings, three of brass, and eight of arsenic, to every 1000 lbs.

*Yellow.*—Four oz. white enamel, two oz. Naples, and a half oz. borax. The oxide of antimony gives a full yellow colour to glass.*

Having premised these remarks upon the art of making glass,—upon the nature of the raw materials in ordinary use for that purpose,—upon the progress which we have made during the last few years as compared to our continental competitors, we shall now enter into a somewhat minute analysis of the contents of the Exhibition, which may be presumed to offer a just and unerring test of the relative excellence of each, in this department of industry.

First and foremost we must give precedence to the glass fountain, which, by universal consent, is one of the most beautiful objects in the Exhibition,—therefore ought to be treated "as a thing apart." It seems as necessary an appendage to that wondrous structure, as the structure itself does to the great gathering of riches beneath its

* As the writer received the above details for producing colours in glass, so has he given them to the reader. They are not expressed in the precise formulæ that science requires; nevertheless, they may afford a useful hint to the practical reader.

roof, and for which it forms such an appropriate receptacle. From that centre of beauty you may radiate to any point of the enchanting circle around you, and feast your eyes upon the fascinating objects that you encounter in almost every direction, yet the mind lingers on the fountain, as though it were the radiant image of a dream and not a sparkling object of reality. But we must descend from the region of enraptured expression to that of sober disquisition, although we might plead an excuse for such indulgence in having watched the progress of that marvellous structure, from the almost rude materials to its present truly attractive form. The practical mind of the age has already classed the fountain amongst the marvels of industrial art, not only for the beauty and originality of its conception, but, also, for the novel appliance of such materials in realizing it. Who now will presume to fix the limits of the application of glass, with this beautiful demonstration before his eyes of its almost infinite uses? As a material for manipulative skill it has no equal, when measured by the multitude of our social and domestic wants. Thus does genius conduct man to a better existence, by a thousand different ways, and by putting every day within his reach a multitude of new and unexpected enjoyments and uses.

As far as the details of the fountain are concerned, we shall content ourselves with simply stating that it measures twenty-seven feet in height, and has absorbed four tons of metal—certainly the largest structure of its kind in the whole world. The candelabra made for Her Majesty by Messrs. Osler have the same amount of excellence, and display similar good taste. This firm has carried the art of making flint glass to its present perfection; it is not merely in transparency of light, in the diaphanous purity of the metal, but in the diamond-like property which it possesses of sending back the rays to the eye in greater brilliancy than it receives them. In these important respects we are far a-head of the whole continent. The large chandelier of Messrs. Pellatt is an equally striking corroboration that we have wonderfully progressed in the manufacture of glass, especially as applied to light ornaments and similarly decorative purposes. So also does that of Messrs. Perry, whose singular construction and arrangement give it the appearance of a beautifully fractured mass of crystal. The taste, the design, and the execution of both these large objects of ornamental use, at once attest the richness and ingenuity we are capable of displaying in this branch of manufacture, and, measured by past productions, conclusively prove how rapid a stride we must have taken. There is little in the co-

loured crystal chandeliers to recommend them, except their novelty; and that too frequently is a doubtful feature for recommendation.

In the "cutting" branch of the manufacture we exhibit to great advantage. The glasses, decanters, fruit and flowered vases of Messrs. Lloyd and Summerfield, hold a high place, not only for the beauty and purity of the material used, but also for the exquisite nicety of finish which they display. Neither in the Belgian, the French, nor in the Austrian departments, is there a single object approachable to them, in either of the respects pointed out. In the contributions of Messrs. Bacchus and Pellatt there are likewise some fine specimens in the same branch. The imitation of the Koh-i-noor, and a dessert service of rare effect, from its simplicity of character, are highly creditable to the latter firm; while the elegant wine-glasses, with their delicately devised stems, of the former, attract general admiration. Nor ought we to omit noticing the thistle-pattern service of Mr. Green, St. James's-street, which is beautifully executed. The Brooklyn Flint Glass Company (America) have contributed some creditable specimens of cut glass, but the metal itself is not so pure as ours.

In fashion, form, beauty of material, and exquisitely finished work, we excel the foreigner in this branch of glass manufacture.

In the coloured and fancy branches there must be great diversity of opinion. In some things we are slightly in advance of our foreign competitors, in many we are fully equal to them, but in a few they still bear away the palm of excellence. First, as to the form and fancy of design. In some instances the French surpass us, in several the Austrians, and especially is it manifest in the collection of Count Harrach, the most beautiful contribution of glass in the whole Exhibition. Yet many of our decanters, wine-glasses, and general objects of utility, excel the same class of productions, whether French or Austrian; but in the higher regions of taste, where the subdued grandeur of ornamentation is required, let us confess at once that we must be content to follow, at least for a time. Some of the flower-stands and vases in the Austrian collection are strikingly beautiful, not only as regards the originality of design but the chasteness of ornamentation, yet withal partaking of the richly-decorative qualities of art. The French are much behind the Austrians in this respect, although they have a style of their own, which has its peculiar excellence, and, in one or two points, is well worthy of notice by our manufacturers. We allude to their peculiar style of enamelling, which is at once chaste and original.

In the coloured department of our own manufacturers we have some highly creditable contributions. The chrysoprase objects of Lloyd and Summerfield are singularly fine in colour; so are the ruby and purple of Rice, Harris, and Co.; nor ought we to pass over the exquisite yellows of Bacchus and Son, especially when united with an alabaster material.

The *gilding* of glass is an art practised to greater perfection abroad than here. The Bohemians particularly excel in this art, being the first, we believe, to apply it to the ornamentation of glass. The gilding is produced by the brown oxide of gold, which is ground up with a flux, and ultimately with a fat oil. It is worked with a brush, and is then submitted to a heat sufficient to melt the flux. It is then laid to cool, when it presents a dull appearance, after which it is burnished with stone burnishers, which gives it a brilliancy. The *enamelling* of glass is produced from a metallic oxide in connexion with a flux, which melts and vitrifies at a lower temperature than the object to be enamelled. The enamel is ground upon a glass slab with a glass muller, and some essential oil, and is applied with a brush. A skilful enamellist understands the effect of heat on colours, otherwise he could not practise his art. If the muffler offers too great a temperature, the colour flies, or the object is distorted and becomes worthless.

The Bohemians are particularly skilful in both these branches of the art, and the French have their peculiar excellence in each, especially in gilding. Nor have we been negligent in imitating the foreigner, in both respects, as our specimens at the Exhibition clearly show. The contribution of Greathead and Green, of Stourbridge, is singularly effective as regards the ornamentation by means of colour and enamel. Their jars and vases, in the Egyptian and Etruscan styles, both in gilding and painting, are quite new in their way, and appear to have opened up a fresh avenue for the application of art to glass. Among the curious applications of art and industry to make glass either ornamental or useful, there are several specimens contributed to the Exhibition. First, perhaps, in importance is the *silvering* of glass by Mr. Hale Thomson, which has added a richness and beauty of colouring to that material of which few could deem it capable of receiving. The process is simple.* The metal is precipitated on the glass by a preparation of grape sugar, which has the property of precipitating silver from its solution. The glass is made with a space between its two sides; this is filled with a neutral

* Vide Hunt's *Synopsis*.

solution of silver, to which some grape sugar has been added, and the beautifully pure coating of that metal is thus produced. The solution being removed, and the interior washed and dried, it is sealed from the effects of air. By this means, under a surface of glass, is obtained the effects of metallic reflection, which cannot change unless the glass is "broken."

The *marble* glass, or *silexalated* marble, of Mr. G. Shove, is another example of the almost infinite application of which the material is capable of. Here we have produced the beautiful and diversified graining of marble, as though it were the production of the mine; indeed, the richness and variety of the veins greatly exceed those of nature, while the polished surface of the material reflects the colours more brightly and distinctly than the stone, whatever amount of art may be bestowed upon it, For useful and for decorative purposes it must prove effective, as its hardness, durability, and easily-cleaned surface must render it of general and of easy appliance.

Again, there is Mr. Kidd's discovery of *embroidering* glass, which imparts so beautiful and chaste an embellishment to that material. The character of the invention renders it capable of varied application. The process consists in cutting some design upon the glass, then silvering it over with a metallic surface, which gives the design a strongly-defined and frost-like relief, although perfectly smooth to the touch, the work being introduced on the underside of the glass When viewed from the front, the designs have the appearance of the purest silver raised from the surface of the glass, as though they had been let into the material; nor can they be tarnished, but will endure in all their freshness and beauty, as long as the material upon which they are impressed. This beautiful invention will give a strong stimulus to the decorative art, especially where elegance, purity of taste, and neatness of execution, are the leading desiderata.

In plate-glass we have no equals, as the mirror at the Exhibition clearly proves, although it is somewhat too large to show our skill to perfection. Swinburne, of South Shields, exhibits to us a new specimen of plate-glass, which, if comparatively economical, may be applied in a variety of ornamental and useful ways. It is opaque, and coloured so as to appear like marble, and the veins which intersect the sheets give it, at first sight, the appearance of that stone; but the high polish and smooth surface which it has received soon undeceives the eye. It is curious; it may, by skilful application, become highly useful, as well as ornamental. But the contributions of the Messrs. Chance, to whose establishment we have cursorily

drawn attention, partake of, perhaps, the deepest interest of any in the glass department of industry. Before they applied their capital and energy to this branch of manufacture, we regularly imported our shades, our crown and flint glass, and the greater portion of our ornamental glass, either from Germany or from France; but now, through the agency of these enterprising manufacturers, we can supply our Continental friends with a superior article, in almost every respect, to what we were formerly glad to receive from them. The shades in the present Exhibition are larger in size than any ever blown before, and the largest amongst them was, we believe, blown by an Englishman. This is a significant fact, seeing that but a few years since this branch of industry, even at Spon Lane, was in the hands of the foreigner. The latter would have laughed at an Englishman attempting to do such a thing; now an Englishman can perform a feat of manual dexterity—and a rare feat it is—superior to the foreigner, be he German, Belgian, or French. We make this observation simply to mark the progress which this branch of industry has made, within these last few years especially. The specimens of window glass, mirror plates, and, above all, of their glass for optical purposes, are highly creditable to the energy and industry which have been exercised in their production. So, also, is their lighthouse, which is so constructed that, while it preserves the light from all the influences of weather, it also imparts it more strongly and to a greater distance than the ordinary structures do; and to that extent it becomes an object of the highest interest, not only to the money calculations of the merchant, but also to the more holy feelings of the philanthropist.

*Glass for Optical Purposes.*—The difficulty and uncertainty attendant upon the manufacture of glass for optical purposes are much greater than any one, unacquainted with the subject, could possibly imagine. The repeal of the Excise laws upon glass has materially diminished the difficulty which, preceding that event, no person would venture to encounter; still, there are difficulties incidental to the nature of the materials used, which no legislative enactment can in the least control. We may as well, however, adduce an instance or so of the injurious effect of the Excise law upon this branch of manufacture, as it will serve to show the impolicy of all fiscal restrictions upon industry, which is scarcely conceivable until practical experience demonstrates its effect. The Society of Arts offered a large premium, for a series of years, to any one who would produce a piece of flint glass, fit for optical purposes, of not less than one cwt. No manufacturer would venture to accept

the offer, for the reasons stated; and the private chemists were debarred by the penalties of the Excise laws, which were too onerous to be disregarded. For instance, any one "convicted of melting glass, for the purpose of any art or manufacture, of the weight of one pound, was liable to the penalty of £100 for the same, with treble costs of action, and a further sum of £100 for annealing or attempting to anneal the same." The Polytechnic Society, however, ventured to disregard the law, but they were soon called to account, and brought to obey its dread commands. The Society, when first started, thought that they might try the experiment, as no one could possibly think that they desired to injure the revenue, therefore constructed a laboratory for the purpose of experimentalizing, and deciding, if possible, on the ingredients requisite to produce optical glass. The society were proceeding prosperously, when the Excise officials paid them a visit, and insisted upon the immediate demolition of their furnaces, or to abide the results of a prosecution: they were too sagacious not to listen to the first alternative. The furnaces were at once taken down, and no similar attempt was made in this country for several years. By a singular incident, however. the art of manufacturing optical glass is now known and practised in this country, irrespective of the repeal of the Excise laws. On the fall of Louis Phillippe, the extensive glass-works of Choisy le Roi were broken up, and the choice collection of workmen, the result of many years' care and discrimination, were scattered here and there in search of a livelihood. M. Bontemps, whose fine practical knowledge was recognized throughout Europe, came to England and offered his services to Messrs. Chance, to whom he had been long and intimately known. This enterprising firm availed themselves of the offer, and mainly, we believe, through the instrumentality of that enlightened Frenchman, have succeeded in the manufacture of optical glass. The specimen of their manufacture in the Exhibition is, we are assured, beyond all precedent both in size and value. Mr. Ross's *Monstre Telescope*, in the western nave, has an object-glass measuring $11\frac{1}{2}$ inches in diameter; but when compared with that of Messrs. Chance, marked No. 22, class 24, in the collection of object-glasses, it is greatly diminished in value. The glass of the latter firm measures 29 inches in diameter, and is stated to be worth £1500. We shall now briefly detail the mode of manufacturing this curious and highly interesting contribution. The preceding pages contain the different processes of making ordinary crown and flint glass, but the process of manufacturing optical glass is essentially different. Instead of "gathering" it,

as it is technically called, the mass is left to cool gradually in the pot, and, when perfectly cold, the latter is spilled or broken off like the peeling of an orange. The bulk is then placed under a set of frame-saws, the blades of which are made of soft iron, when, by the action of emery and water, it is cut into slices or slabs varying from half to one and a half inches in thickness. At Messrs. Chance's manufactory the saws are worked by machinery. The slabs are then cut into round discs, care being taken to avoid the air bubbles; they are then taken to the glass-cutter, who scallops a piece out of six or eight equally distant parts on the edge of the disc, and opposite to each other. These parts being polished, the interior of the glass is perfectly visible, though the face of the glass remains as rough as when sawn; by which means any internal defect may be detected, such as *striæ*, for instance, and remedied by subsequent annealing. The advantage of this process of manufacture is apparent, as the glass, being kept for sometime undisturbed in a molten state, causes the impurities either to fall to the bottom or rise to the top as scum, both of which can be cut off with the saw and leave the mass comparatively pure.

However pure and transparent may be the body of the glass thus prepared, there are still difficulties which are not easily overcome. So much so, indeed, is this the case, that when a disc of large size is produced, *perfectly faultless*, its value can scarcely be calculated, as the list of Messrs. Chance's prices for optical glasses clearly proves, for the difference of a *few* inches in diameter causes a difference of *many* pounds in price:—

LIST OF DISC PRICES.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 inches diameter . | £0 | 15 | 6 | 12 inches diameter . | £48 | 0 | 0 |
| 6 „ . | 7 | 18 | 0 | 15 „ . | 110 | 0 | 0 |
| 9 „ . | 24 | 15 | 0 | | | | |

Limited space prevents us pursuing this interesting subject further, therefore must we content ourselves with giving the respective density of glass best suited for optical purposes:—

| | |
|---|---|
| Taking the unit of water as . . . | 1 |
| Flint-glass should be . . . . | 3.54 |
| Crown glass . . . . . | 2.7 |

Hitherto we have been principally dependent upon France for our optical glasses, but the change we have indicated above has already reversed the condition of the manufacture, especially when large objects are required, and our neighbours are already availing themselves of the change to suit their peculiar requirements.

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